70304

APPENDIX J

LANDFILL REFUSE AND LEACHATE VOLUME DATA

APPENDIX J-1

REFUSE VOLUME CALCULATION DATA

Appendix J-1
REFUSE VOLUME CALCULATION
Woodstock Municipal Landfill Site
Woodstock Illinois

GRID #	AREA IN GRID (SQ FT)	% GRID COVERED BY LANDFILL	LANDFILL AREA IN GRID (SQ FT)	THICKNESS OF REFUSE (FT)	REFUSE VOLUME IN GRID (CUBIC FEET) (AREA x THICKNESS)
D1	62500	10%	6250	0.5	3,125
E1	62500	20%	12500	0.5	6,250
F1	62500	20%	12500	0.5	6,250
G1	62500	15%	9375	0.5	4,688
A2	62500	15%	9375	0.5	4,688
B2	62500	80%	50000	4	200,000
C2	62500	70%	43750	4	175,000
D2	62500	80%	50000	5	250,000
E2	62500	100%	62500	7	437,500
F2	62500	80%	50000	6	300,000
G2	62500	20%	12500	1	12,500
B3	62500	80%	50000	6	300,000
C3	62500	100%	62500	6.5	406,250
D3	62500	100%	62500	11	687,500
E3	62500	100%	62500	15.5	968,750
F3	62500	100%	62500	11	687,500
G3	62500	85%	53125	6	318,750
H3	62500	25%	15625	3	46,875
B4	62500	45%	28125	5	140,625
C4	62500	100%	62500	5.5	343,750
D4	62500	100%	62500	9.5	593,750
E4	62500	100%	62500	10.5	656,250
F4	62500	100%	62500	13.5	843,750
G4	62500	100%	62500	12	750,000
H4	62500	30%	18750	8	150,000
B5	62500	10%	6250	0.5	3,125
C5	62500	100%	62500	4	250,000
D5	62500	100%	62500	4.5	281,250
E5	62500	100%	62500	7.5	468,750
F5	62500	100%	62500	11.5	718,750
G5	62500	100%	62500	14	875,000
H5	62500	25%	15625	6	93,750
C6	62500	80%	50000	2	100,000
D6	62500	90%	56250	4	225,000
E6	62500	90%	56250	5	281,250
F6	62500	90%	56250	10	562,500
G6	62500	60%	37500	10	375,000
H6	62500	5%	3125	10	31,250

TOTAL LANDFILL AREA = 1,600,000 SQ FEET
37 ACRES

AVG REFUSE THICKNESS = 7.6 FT

TOTAL REFUSE VOLUME = 13,000,000 CUBIC FEET

Notes: Grid square locations indicated in Figure 4-3
Assigned refuse thickness values are based on borings at leachate well locations (Appendix B-1)

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 WOODSTOCK MUNICIPAL LANDFILL SITE
 SIMULATION.18
 APRIL 24, 1991

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                              FAIR GRASS

                               LAYER  1
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                      VERTICAL PERCOLATION LAYER
   THICKNESS                                =      12.00 INCHES
   POROSITY                                 =       0.4370 VOL/VOL
   FIELD CAPACITY                           =       0.1053 VOL/VOL
   WILTING POINT                            =       0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT               =       0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY         =       0.005100000184 CM/SEC


                               LAYER  2
                               --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                                =      91.00 INCHES
   POROSITY                                 =       0.5200 VOL/VOL
   FIELD CAPACITY                           =       0.2942 VOL/VOL
   WILTING POINT                            =       0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT               =       0.2942 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY         =       0.000199999995 CM/SEC


                        GENERAL SIMULATION DATA
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   SCS RUNOFF CURVE NUMBER                  =        58.20
   TOTAL AREA OF COVER                      = 1500000. SQ FT
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EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	9.4040 INCHES
INITIAL VEG. STORAGE	=	4.5116 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	28.0358 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
ID OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	0.94	2.71	4.37	2.49	4.60
	4.87	4.08	3.42	2.66	2.38	2.04
STD. DEVIATIONS	1.11	0.49	1.35	1.39	0.99	1.67
	4.14	1.48	1.49	1.29	0.25	0.65
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.028	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.063	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.670	1.198	2.065	3.184	2.899	4.514
	4.314	4.266	2.656	2.038	1.077	0.798

STD. DEVIATIONS	0.254	0.185	0.368	0.705	1.162	1.163
	2.664	0.919	1.232	0.672	0.257	0.289

PERCOLATION FROM LAYER 2

TOTALS	0.5232	0.4754	0.5679	0.5878	0.6014	0.5138
	0.7133	0.6498	0.4570	0.3806	0.3420	0.4220
STD. DEVIATIONS	0.2264	0.2172	0.2703	0.3582	0.2573	0.1832
	0.4597	0.4563	0.2566	0.1850	0.1452	0.1902

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	36.03	(6.599)	4503500.	100.00
RUNOFF	0.028	(0.063)	3543.	0.08
EVAPOTRANSPIRATION	29.680	(4.705)	3709945.	82.38
PERCOLATION FROM LAYER 2	6.2341	(2.6035)	779263.	17.30
CHANGE IN WATER STORAGE	0.086	(1.109)	10749.	0.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.51	438750.0
RUNOFF	0.142	17714.0
PERCOLATION FROM LAYER 2	0.0747	9341.8
SNOW WATER	1.02	127746.4

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3593
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0838

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.88	0.1566
2	27.81	0.3056
SNOW WATER	0.00	

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 WOODSTOCK MUNICIPAL LANDFILL SITE
 SIMULATION.19
 APRIL 24, 1991

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                            FAIR GRASS

                             LAYER  1
                             --------

                    VERTICAL PERCOLATION LAYER
   THICKNESS                            =      60.00 INCHES
   POROSITY                             =       0.4370 VOL/VOL
   FIELD CAPACITY                       =       0.1053 VOL/VOL
   WILTING POINT                        =       0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT           =       0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY     =       0.005100000184 CM/SEC


                             LAYER  2
                             --------

                    VERTICAL PERCOLATION LAYER
   THICKNESS                            =      91.00 INCHES
   POROSITY                             =       0.5200 VOL/VOL
   FIELD CAPACITY                       =       0.2942 VOL/VOL
   WILTING POINT                        =       0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT           =       0.2942 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY     =       0.000199999995 CM/SEC


                      GENERAL SIMULATION DATA
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   SCS RUNOFF CURVE NUMBER              =       58.20
   TOTAL AREA OF COVER                  = 1500000. SQ FT
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EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.7400 INCHES
INITIAL VEG. STORAGE	=	3.4833 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	33.0902 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
END OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	0.94	2.71	4.37	2.49	4.60
	4.87	4.08	3.42	2.66	2.38	2.04
STD. DEVIATIONS	1.11	0.49	1.35	1.39	0.99	1.67
	4.14	1.48	1.49	1.29	0.25	0.65
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.032	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.071	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.676	1.173	1.978	2.946	2.833	4.366
	4.220	4.137	2.605	2.038	1.070	0.802

STD. DEVIATIONS	0.265	0.170	0.431	0.755	1.006	1.173
	2.662	0.908	1.179	0.552	0.268	0.290

PERCOLATION FROM LAYER 2

TOTALS	0.5074	0.4695	0.5385	0.5733	0.6241	0.5653
	0.7126	0.7244	0.5703	0.5005	0.4437	0.4765
STD. DEVIATIONS	0.2605	0.2341	0.2736	0.3459	0.3027	0.2358
	0.3725	0.4476	0.3102	0.2511	0.1983	0.2021

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	36.03	(6.599)	4503500.	100.00
RUNOFF	0.032	(0.071)	3983.	0.09
EVAPOTRANSPIRATION	28.844	(4.329)	3605532.	80.06
PERCOLATION FROM LAYER 2	6.7061	(2.9943)	838264.	18.61
CHANGE IN WATER STORAGE	0.446	(1.728)	55722.	1.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.51	438750.0
RUNOFF	0.159	19914.5
PERCOLATION FROM LAYER 2	0.0561	7016.8
SNOW WATER	1.02	127746.4

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2915

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0464

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	4.94	0.1648
2	37.68	0.3140
SNOW WATER	0.00	

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WOODSTOCK MUNICIPAL LANDFILL SITE
SIMULATION.20
APRIL 24, 1991

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	30.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.005100000184 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	120.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	58.20
TOTAL AREA OF COVER	=	1500000. SQ FT

EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.7400 INCHES
INITIAL VEG. STORAGE	=	3.4832 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	38.4630 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
END OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	0.94	2.71	4.37	2.49	4.60
	4.87	4.08	3.42	2.66	2.38	2.04
STD. DEVIATIONS	1.11	0.49	1.35	1.39	0.99	1.67
	4.14	1.48	1.49	1.29	0.25	0.65
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.032	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.071	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.676	1.173	1.978	2.946	2.833	4.366
	4.220	4.137	2.605	2.038	1.070	0.802

STD. DEVIATIONS	0.265	0.170	0.431	0.755	1.006	1.173
	2.662	0.908	1.179	0.552	0.268	0.290

PERCOLATION FROM LAYER 2

TOTALS	0.4216	0.4216	0.4826	0.5311	0.5837	0.5532
	0.6534	0.7467	0.6063	0.5255	0.4485	0.4469
STD. DEVIATIONS	0.2860	0.2697	0.3020	0.3669	0.3644	0.3020
	0.3633	0.5260	0.3828	0.3014	0.2336	0.2130

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	36.03	(6.599)	4503500.	100.00
RUNOFF	0.032	(0.071)	3983.	0.09
EVAPOTRANSPIRATION	28.843	(4.329)	3605404.	80.06
PERCOLATION FROM LAYER 2	6.4211	(3.5361)	802638.	17.82
CHANGE IN WATER STORAGE	0.732	(2.042)	91476.	2.03

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.51	438750.0
RUNOFF	0.159	19914.3
PERCOLATION FROM LAYER 2	0.0534	6670.2
SNOW WATER	1.02	127746.4
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2915	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0464	

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	10.17	0.1696
2	28.66	0.3149
SNOW WATER	0.00	

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WOODSTOCK MUNICIPAL LANDFILL SITE
SIMULATION.21
APRIL 29, 1991

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	30.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.005100000184 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	91.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	58.20
TOTAL AREA OF COVER	=	1640000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES

UPPER LIMIT VEG. STORAGE	=	8.7400 INCHES
INITIAL VEG. STORAGE	=	3.4832 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	29.9312 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
END OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	0.94	2.71	4.37	2.49	4.60
	4.87	4.08	3.42	2.66	2.38	2.04
STD. DEVIATIONS	1.11	0.49	1.35	1.39	0.99	1.67
	4.14	1.48	1.49	1.29	0.25	0.65
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.032	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.071	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.676	1.173	1.978	2.946	2.833	4.366
	4.220	4.137	2.605	2.038	1.070	0.802

STD. DEVIATIONS	0.265	0.170	0.431	0.755	1.006	1.173
	2.662	0.908	1.179	0.552	0.268	0.290

PERCOLATION FROM LAYER 2

TOTALS	0.5307	0.4872	0.5630	0.6067	0.6637	0.5853
	0.7901	0.7652	0.5583	0.4705	0.4145	0.4628
STD. DEVIATIONS	0.2622	0.2315	0.2750	0.3694	0.3043	0.2252
	0.4647	0.5050	0.3062	0.2328	0.1835	0.2148

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	36.03	(6.599)	4923827.	100.00
RUNOFF	0.032	(0.071)	4355.	0.09
EVAPOTRANSPIRATION	28.844	(4.329)	3942019.	80.06
PERCOLATION FROM LAYER 2	6.8980	(3.0030)	942722.	19.15
CHANGE IN WATER STORAGE	0.254	(1.404)	34732.	0.71

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.51	479700.0
RUNOFF	0.159	21773.2
PERCOLATION FROM LAYER 2	0.0740	10108.8
SNOW WATER	1.02	139669.5

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2915

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0464

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	4.94	0.1648
2	28.31	0.3111
SNOW WATER	0.00	

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 WOODSTOCK MUNICIPAL LANDFILL SITE
 SIMULATION.22
 APRIL 29, 1991

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	30.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.005100000184 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	91.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	70.00
TOTAL AREA OF COVER	=	1500000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES

UPPER LIMIT VEG. STORAGE	=	8.7400 INCHES
INITIAL VEG. STORAGE	=	3.4832 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	29.9312 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
END OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	0.94	2.71	4.37	2.49	4.60
	4.87	4.08	3.42	2.66	2.38	2.04
STD. DEVIATIONS	1.11	0.49	1.35	1.39	0.99	1.67
	4.14	1.48	1.49	1.29	0.25	0.65
RUNOFF						
TOTALS	0.004	0.000	0.000	0.000	0.000	0.000
	0.121	0.001	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.008	0.000	0.000	0.000	0.000	0.000
	0.270	0.001	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.676	1.173	1.978	2.946	2.833	4.366
	4.220	4.137	2.605	2.038	1.070	0.802

STD. DEVIATIONS	0.265	0.170	0.431	0.755	1.006	1.173
	2.662	0.908	1.179	0.552	0.268	0.290

PERCOLATION FROM LAYER 2

TOTALS	0.5277	0.4851	0.5611	0.6051	0.6627	0.5847
	0.7526	0.7408	0.5486	0.4649	0.4111	0.4602
STD. DEVIATIONS	0.2594	0.2292	0.2730	0.3673	0.3032	0.2246
	0.3958	0.4599	0.2892	0.2232	0.1782	0.2120

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	36.03	(6.599)	4503500.	100.00
RUNOFF	0.125	(0.269)	15625.	0.35
EVAPOTRANSPIRATION	28.844	(4.330)	3605539.	80.06
PERCOLATION FROM LAYER 2	6.8047	(2.8872)	850583.	18.89
CHANGE IN WATER STORAGE	0.254	(1.388)	31753.	0.71

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.51	438750.0
RUNOFF	0.598	74777.1
PERCOLATION FROM LAYER 2	0.0625	7811.9
SNOW WATER	1.02	127746.4
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2851	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0464	

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	4.94	0.1648
2	28.31	0.3111
SNOW WATER	0.00	

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 WOODSTOCK MUNICIPAL LANDFILL SITE
 SIMULATION.24
 MAY 10, 1991

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	36.00 INCHES
POROSITY	=	0.3980 VOL/VOL
FIELD CAPACITY	=	0.2443 VOL/VOL
WILTING POINT	=	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2443 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000360000005 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	36.00 INCHES
POROSITY	=	0.4710 VOL/VOL
FIELD CAPACITY	=	0.3418 VOL/VOL
WILTING POINT	=	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3418 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000042000000 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	60.00 INCHES
POROSITY	=	0.5200 VOL/VOL

FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	85.56
TOTAL AREA OF COVER	=	1500000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	7.9600 INCHES
INITIAL VEG. STORAGE	=	5.2200 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	38.7516 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
END OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	0.94	2.71	4.37	2.49	4.60
	4.87	4.08	3.42	2.66	2.38	2.04
STD. DEVIATIONS	1.11	0.49	1.35	1.39	0.99	1.67

	4.14	1.48	1.49	1.29	0.25	0.65

RUNOFF

TOTALS	0.112	0.000	0.024	0.044	0.008	0.142
	0.636	0.190	0.038	0.059	0.014	0.008
STD. DEVIATIONS	0.250	0.000	0.039	0.062	0.019	0.119
	1.139	0.216	0.051	0.082	0.016	0.011

EVAPOTRANSPIRATION

TOTALS	0.670	1.210	2.331	3.591	3.186	4.598
	4.083	3.992	2.637	2.318	1.125	0.803
STD. DEVIATIONS	0.252	0.197	0.289	0.313	1.599	1.342
	2.779	0.850	1.354	0.771	0.266	0.292

PERCOLATION FROM LAYER 3

TOTALS	0.2382	0.2475	0.3118	0.3914	0.4400	0.4047
	0.3837	0.3689	0.3341	0.3141	0.2756	0.2647
STD. DEVIATIONS	0.1039	0.1128	0.1499	0.2325	0.2816	0.2328
	0.1936	0.1790	0.1592	0.1404	0.1138	0.0965

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	36.03	(6.599)	4503500.	100.00
RUNOFF	1.275	(1.190)	159342.	3.54
EVAPOTRANSPIRATION	30.544	(4.939)	3818020.	84.78
PERCOLATION FROM LAYER 3	3.9745	(1.9087)	496814.	11.03
CHANGE IN WATER STORAGE	0.235	(1.032)	29324.	0.65

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.51	438750.0
RUNOFF	2.133	266618.0

PERCOLATION FROM LAYER 3	0.0273	3408.1
SNOW WATER	1.02	127746.4

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3315
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1358

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	9.19	0.2552
2	12.62	0.3506
3	18.18	0.3030
SNOW WATER	0.00	

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 WOODSTOCK MUNICIPAL LANDFILL SITE
 SIMULATION.26
 MAY 24, 1991

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                           EXCELLENT GRASS

                              LAYER  1
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                    VERTICAL PERCOLATION LAYER
  THICKNESS                           =      30.00 INCHES
  POROSITY                            =       0.4370 VOL/VOL
  FIELD CAPACITY                      =       0.1053 VOL/VOL
  WILTING POINT                       =       0.0466 VOL/VOL
  INITIAL SOIL WATER CONTENT          =       0.1053 VOL/VOL
  SATURATED HYDRAULIC CONDUCTIVITY    =       0.008500000462 CM/SEC


                              LAYER  2
                              --------

                    VERTICAL PERCOLATION LAYER
  THICKNESS                           =      91.00 INCHES
  POROSITY                            =       0.5200 VOL/VOL
  FIELD CAPACITY                      =       0.2942 VOL/VOL
  WILTING POINT                       =       0.1400 VOL/VOL
  INITIAL SOIL WATER CONTENT          =       0.2942 VOL/VOL
  SATURATED HYDRAULIC CONDUCTIVITY    =       0.000199999995 CM/SEC


                      GENERAL SIMULATION DATA
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  SCS RUNOFF CURVE NUMBER             =       40.48
  TOTAL AREA OF COVER                 = 1500000. SQ FT
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EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.7400 INCHES
INITIAL VEG. STORAGE	=	3.3973 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	29.9312 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
END OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	0.94	2.71	4.37	2.49	4.60
	4.87	4.08	3.42	2.66	2.38	2.04
STD. DEVIATIONS	1.11	0.49	1.35	1.39	0.99	1.67
	4.14	1.48	1.49	1.29	0.25	0.65
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.676	1.173	1.979	2.946	2.834	4.354
	4.175	4.114	2.595	2.042	1.072	0.803

STD. DEVIATIONS	0.265	0.171	0.432	0.756	1.006	1.191
	2.686	0.931	1.181	0.554	0.270	0.291

PERCOLATION FROM LAYER 2

TOTALS	0.5415	0.4947	0.5717	0.6131	0.6728	0.5898
	0.8124	0.7842	0.5677	0.4776	0.4223	0.4719
STD. DEVIATIONS	0.2599	0.2297	0.2743	0.3668	0.2988	0.2220
	0.4915	0.5248	0.3134	0.2386	0.1883	0.2153

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	36.03	(6.599)	4503500.	100.00
RUNOFF	0.000	(0.000)	0.	0.00
EVAPOTRANSPIRATION	28.763	(4.307)	3595390.	79.84
PERCOLATION FROM LAYER 2	7.0196	(3.0333)	877456.	19.48
CHANGE IN WATER STORAGE	0.245	(1.383)	30653.	0.68

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.51	438750.0
RUNOFF	0.000	0.0
PERCOLATION FROM LAYER 2	0.0783	9791.1
SNOW WATER	1.02	127746.4

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2757

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0445

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	4.87	0.1623
2	28.38	0.3119
SNOW WATER	0.00	

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 WOODSTOCK MUNICIPAL LANDFILL SITE
 SIMULATION.27
 MAY 24, 1991

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                               BARE GROUND

                                LAYER  1
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                        VERTICAL PERCOLATION LAYER
   THICKNESS                                =     30.00 INCHES
   POROSITY                                 =      0.4370 VOL/VOL
   FIELD CAPACITY                           =      0.1053 VOL/VOL
   WILTING POINT                            =      0.0466 VOL/VOL
   INITIAL SOIL WATER CONTENT               =      0.1053 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY         =      0.001700000023 CM/SEC


                                LAYER  2
                                --------

                        VERTICAL PERCOLATION LAYER
   THICKNESS                                =     91.00 INCHES
   POROSITY                                 =      0.5200 VOL/VOL
   FIELD CAPACITY                           =      0.2942 VOL/VOL
   WILTING POINT                            =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT               =      0.2942 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY         =      0.000199999995 CM/SEC


                          GENERAL SIMULATION DATA
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   SCS RUNOFF CURVE NUMBER                  =      80.89
   TOTAL AREA OF COVER                      = 1500000. SQ FT
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EVAPORATIVE ZONE DEPTH	=	20.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.7400 INCHES
INITIAL VEG. STORAGE	=	3.6830 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	29.9312 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
END OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.48	0.94	2.71	4.37	2.49	4.60
	4.87	4.08	3.42	2.66	2.38	2.04
STD. DEVIATIONS	1.11	0.49	1.35	1.39	0.99	1.67
	4.14	1.48	1.49	1.29	0.25	0.65
RUNOFF						
TOTALS	0.056	0.000	0.001	0.006	0.000	0.048
	0.373	0.068	0.005	0.013	0.000	0.000
STD. DEVIATIONS	0.125	0.000	0.001	0.010	0.001	0.059
	0.733	0.099	0.011	0.019	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.672	1.170	1.975	2.943	2.831	4.408
	4.333	4.162	2.642	2.033	1.030	0.798

STD. DEVIATIONS	0.258	0.170	0.431	0.755	1.003	1.109
	2.595	0.857	1.130	0.545	0.276	0.289

PERCOLATION FROM LAYER 2

TOTALS	0.4755	0.4488	0.5285	0.5788	0.6348	0.5635
	0.6426	0.6420	0.4915	0.4194	0.3688	0.4122
STD. DEVIATIONS	0.2343	0.2081	0.2573	0.3568	0.2918	0.2210
	0.2821	0.3436	0.2282	0.1747	0.1412	0.1777

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	36.03	(6.599)	4503500.	100.00
RUNOFF	0.571	(0.773)	71357.	1.58
EVAPOTRANSPIRATION	28.997	(4.384)	3624578.	80.48
PERCOLATION FROM LAYER 2	6.2063	(2.5351)	775782.	17.23
CHANGE IN WATER STORAGE	0.254	(1.379)	31784.	0.71

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.51	438750.0
RUNOFF	1.463	182824.5
PERCOLATION FROM LAYER 2	0.0430	5378.7
SNOW WATER	1.02	127746.4

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.2950

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0465

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	5.10	0.1700
2	28.11	0.3089
SNOW WATER	0.00	

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WOODSTOCK MUNICIPAL LANDFILL SITE
SIMULATION.30
OCTOBER 14, 1991

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	30.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.1053 VOL/VOL
WILTING POINT	=	0.0466 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1053 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.005100000184 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	91.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	58.20
TOTAL AREA OF COVER	=	1500000. SQ FT
EVAPORATIVE ZONE DEPTH	=	20.00 INCHES

UPPER LIMIT VEG. STORAGE	=	6.7400 INCHES
INITIAL VEG. STORAGE	=	3.3384 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	29.9312 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CHICAGO ILLINOIS

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	128
END OF GROWING SEASON (JULIAN DATE)	=	282

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
21.40	26.00	36.00	48.80	59.10	68.60
73.00	71.90	64.70	53.50	39.80	27.70

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.17	1.62	4.40	4.46	5.09	8.37
	7.05	5.59	4.30	3.70	3.43	2.69
STD. DEVIATIONS	0.75	0.64	2.14	1.71	2.26	3.06
	3.82	1.34	1.20	2.70	2.87	1.23
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.001	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.003	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	0.592	0.992	2.337	3.233	3.452	5.174
	5.304	4.994	2.908	1.610	1.188	0.565

STD. DEVIATIONS	0.106	0.083	0.204	0.826	0.785	1.076
	1.078	1.399	0.910	0.705	0.367	0.107

PERCOLATION FROM LAYER 2

TOTALS	1.2050	1.0975	1.6218	1.7546	1.5733	1.9527
	2.7366	2.1836	1.3854	1.0784	1.7041	1.6075
STD. DEVIATIONS	0.3139	0.2359	0.8018	0.8823	0.5618	1.0101
	1.8319	1.2033	0.6167	0.4225	0.9601	0.7989

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	52.87	(6.796)	6608999.	100.00
RUNOFF	0.001	(0.003)	167.	0.00
EVAPOTRANSPIRATION	32.349	(3.911)	4043683.	61.18
PERCOLATION FROM LAYER 2	19.9004	(4.9662)	2487552.	37.64
CHANGE IN WATER STORAGE	0.621	(2.026)	77597.	1.17

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.56	445000.0
RUNOFF	0.004	545.9
PERCOLATION FROM LAYER 2	0.3072	38396.8
SNOW WATER	1.89	236105.2
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2801	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0464	

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	5.73	0.1911
2	34.18	0.3757
SNOW WATER	0.00	

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K

APPENDIX K

GROUNDWATER MODELING RESULTS

U.S.G.S Modflow model (Modflow) was used to simulate the groundwater flow system in the upper aquifer at the Woodstock Landfill NPL Site. The model was implemented with the existing hydraulic data for the site.

Modflow is a three-dimensional finite-difference groundwater flow model developed by the U.S. Geological Survey, and is a public domain model, used for this implementation on DOS personal computer. The model simulates groundwater flow within aquifers using a block-centered finite-difference approach. Multiple layers can be simulated as confined, unconfined, or a combination of both. The model can simulate external stresses including: flow to wells, areal recharge, evapotranspiration, flow to drains, flow through riverbeds, and general-head boundary conditions.

Two common uses for models are to evaluate existing aquifer behavior and predict future aquifer behavior. Sufficient data was developed in the Woodstock RI to adequately evaluate the characteristics and behavior of the upper aquifer at the site. The model was not used to extensively evaluate the groundwater flow conditions at the Site, although the model results do correlate well with the observed aquifer behavior at the Site. The primary use for this model will be for evaluating possible remedial alternatives for the Feasibility Study.

MODEL IMPLEMENTATION

The model was implemented in a 2-layer, 28-column, 35-row finite-difference grid with 100-foot grid-spacing. The first layer (upper layer of the model) represents the portion of the upper aquifer above elevation 920 feet. The second layer represents the lower portion of the upper aquifer, from elevation 920, down to the base of the upper aquifer which is at elevation approximately 880 feet at the north end of the site, and 915 feet at the southern end.

The modeling was limited to the upper aquifer. The Yorkville and Tiskilwa clay which underlie the upper aquifer have extremely low hydraulic conductivity, so for the time scale of this model implementation, the upper aquifer is effectively isolated from lower aquifers.

A single consistent set of time and space units are required for the model. The units selected for this implementation were "feet" for length units and "days" for the time unit. The following parameters resulted. Grid spacing, aquifer thickness, and watertable elevation were reported in feet. Hydraulic conductivity units were in feet per day; transmissivity units were in feet-squared per day. Volumes of discharge and recharge were reported in cubic feet per day.

The Strongly Implicit Procedure (SIP) module used to solve model.

MODEL PARAMETERS

Input variables are used in the model to define the: 1) aquifer geometry, 2) boundary conditions, 3) hydraulic characteristics of the aquifer, and 4) recharge/discharge interactions with the atmosphere and surface water bodies. The use of each of these groups of input parameters is discussed below. The attached figure, "Finite Difference Nodes for Modflow Model," displays the orientation of the model over the modeled area, and indicates the boundary conditions used. Specific data gathered during the RI were used for the implementation.

Aquifer Geometry

As is discussed in Section 4 of the RI Report, the upper aquifer in the vicinity of the Woodstock landfill consists of an unconsolidated sand and gravel aquifer which extends beneath most of the landfill. It is wedge-shaped, being 30 to 40 feet thick beneath the northern boundary of the landfill, and thinning to less than five feet at the southeastern end of the landfill, and to less than 20 feet at the southwestern end. Groundwater flows beneath the landfill from the north, and discharges to Kishwaukee Creek, which borders the landfill on the southwestern corner. In addition to the physical thinning of sand and gravel unit from north to south, the water table elevation decreases from north to south from elevation approximately 930 feet to 923 feet. So the resulting aquifer transmissivity, which is based on the total saturated thickness, decreases from north to south.

Boundary Conditions

Boundary conditions used for the simulation were based on a combination of aquifer geometry and water levels on the up and downgradient end of the site. As explained above, the aquifer thins from north to south. Water levels, measured at site monitoring wells and staff gauges on five dates between September 1990 and May 1991 showed that the water table has a quite consistent elevation and orientation across the site throughout the year. The water table elevation appears to be controlled by the open water pond north of the site and Kishwaukee Creek south of the site. The surface water elevation of the open water pond ranged between 935.9 and 936.4 feet, and resulted in a water table elevation beneath the north boundary of the landfill between 930 and 931 feet during the investigation. The surface water elevation in Kishwaukee Creek at the downgradient end ranged between 923.5 and 924.5 feet during the investigation.

For the simulation, IBOUND was used to set a constant head value of 935 feet for model nodes representing the open water pond (identified by -3 values in the IBOUND array for the first layer). A constant head-value was also assigned to the southern western corner (node: row=34, column=2) to provide the gradient toward Kishwaukee Creek from the south which was observed during the investigation.

Hydraulic Properties

Aquifer characteristics are required for each layer of the model. These include: specific yield (storativity), hydraulic conductivity, and transmissivity, vertical hydraulic conductivity between model layers.

Specific Yield for both simulation layers of the upper aquifer was assigned to be SF1 = 0.25. Since the aquifer being simulated is unconfined, it was not necessary to assign a storativity value.

Hydraulic Conductivity. Based on baildown tests conducted at the Phase I monitoring wells, a value of 21 feet/day ($7.5x10^{-3}$ cm/sec) was assumed in the model. See Table 3-5 for calculated values for individual wells.

The 20 feet/day val[Cs was assigned to the first layer. The model calculated the transmissivity for each node, by multiplying the value by the saturated thickness, calculated as the difference between the water table elevation and elevation of the bottom of the layer. The bottom elevation (BOT-1) was assigned as 920 feet in the BCF input file.

Transmissivity values were assigned directly for the lower layer. The values ranged from 400 feet/day along the northern boundary where the aquifer is thickest, to values of 20 feet/day in the southwest, and 0.1 feet/day in southeast where the upper aquifer pinches out.

Vertical Conductivity between simulation layers was set at 0.4 per day which represents a vertical permeability which is equivalent to the horizontal conductivity.

Recharge/Discharge

Recharge is both lateral and vertical. Lateral recharge occurs to the upper aquifer at the north end, where the higher groundwater elevations form the gradient driving groundwater to the south. Areal recharge occurs across the entire surface as result of infiltration of precipitation. For the simulation, lateral recharge is controlled by the constant head assignment at the north end of the model.

Areal recharge was applied in the model only to the landfill nodes, since areas west, south, and east of the landfill are probably dominated by evapotranspiration. The HELP model provided an estimate of 6.9 inches per year infiltration based on a continuous two-foot cover over the entire landfill. The infiltration was applied by model module RCH. The value of 0.00157 feet/day which is equivalent to 6.9 inches/year was applied to most of the landfill. Double that amount (13.8 inches/year) was applied to to the southwest one-third of the landfill.

Primary discharge from the upper aquifer occurs at Kishwaukee Creek. This discharge was simulated by setting the surface water levels of the nodes representing the creek to 923.5 feet. The drainage by Kishwaukee Creek extends in a marshy area aligned along the bottom of the landfill. The Kishwaukee Creek model nodes are indicated by shaded 3's on the attached figure.

Secondary discharge occurs in marshy areas along the north end of the landfill on both the east and west boundary. In the water table maps generated for the RI Report, the 930-foot water table contour line consistently coincides with 930-foot ground surface contour line extending to the northwest from the northwest part of the landfill. This indicates discharge to surface, and it is simulated in the model by assigning "drain" values of 930 feet at the appropriate nodes. The wetland located to the east of the north end of the landfill, is similarly represented, with drain values of 928 feet. These "drains" are indicated by shaded 2's on the attached figure.

SIMULATION RESULTS

The model was not extensively calibrated. If the model is used for extensive evaluation of remedial alternatives in the feasibility study, detailed sensitivity analyses will be conducted, with the appropriate variables. Input values will reflect the most current information available for the Site.

FINITE DIFFERENCE NODES FOR MODFLOW MODEL

Columns --->

Rows | V	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
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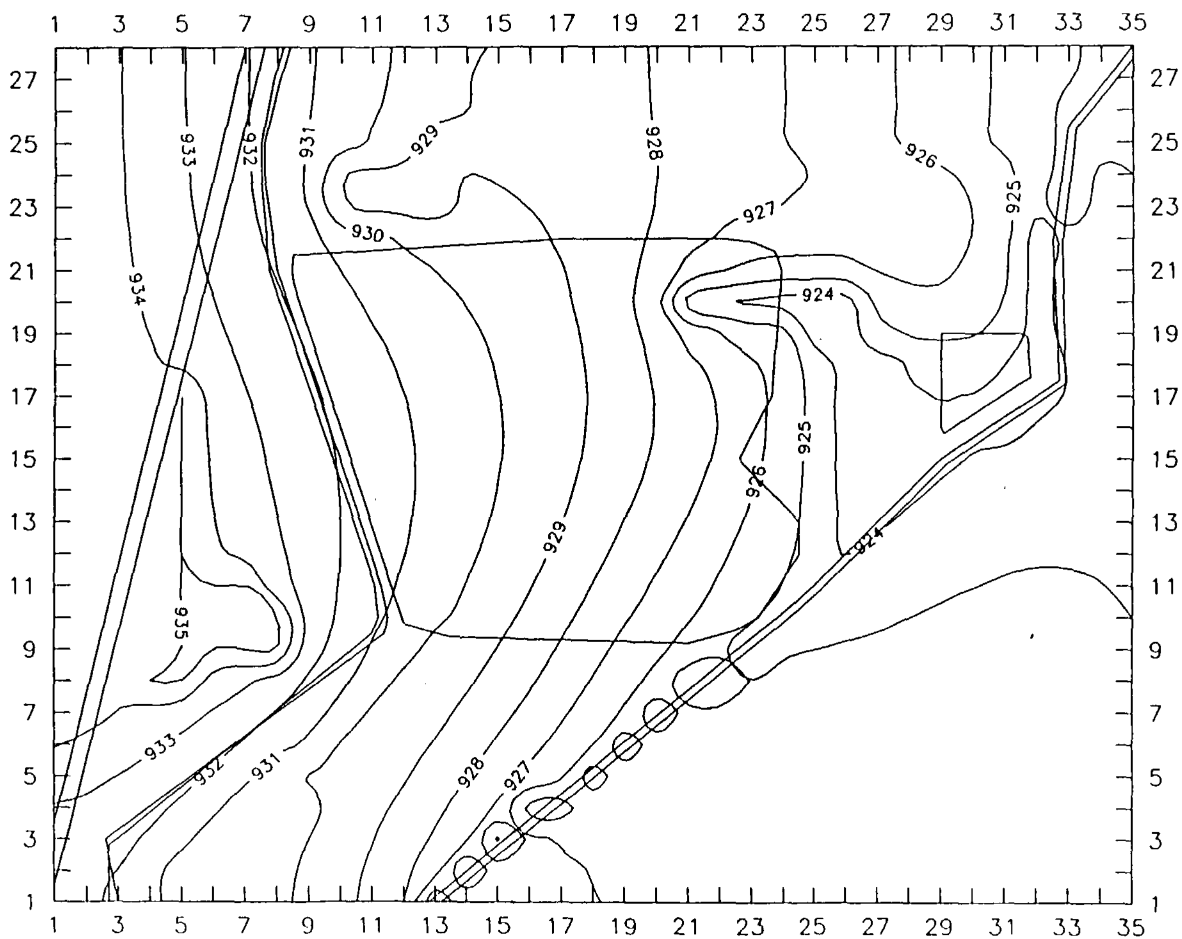
Legend

- 0 = Inactive Cells
- -1 = Constant Head boundaries
- 1 = Dependent Cells
- 2 = Wetland Cells
- 3 = Kishwaukee Creek Cells
- 5 = Landfill Cells

Layer 1



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27 25 23 21 19 17 15 13 11 9 7 5 3 1
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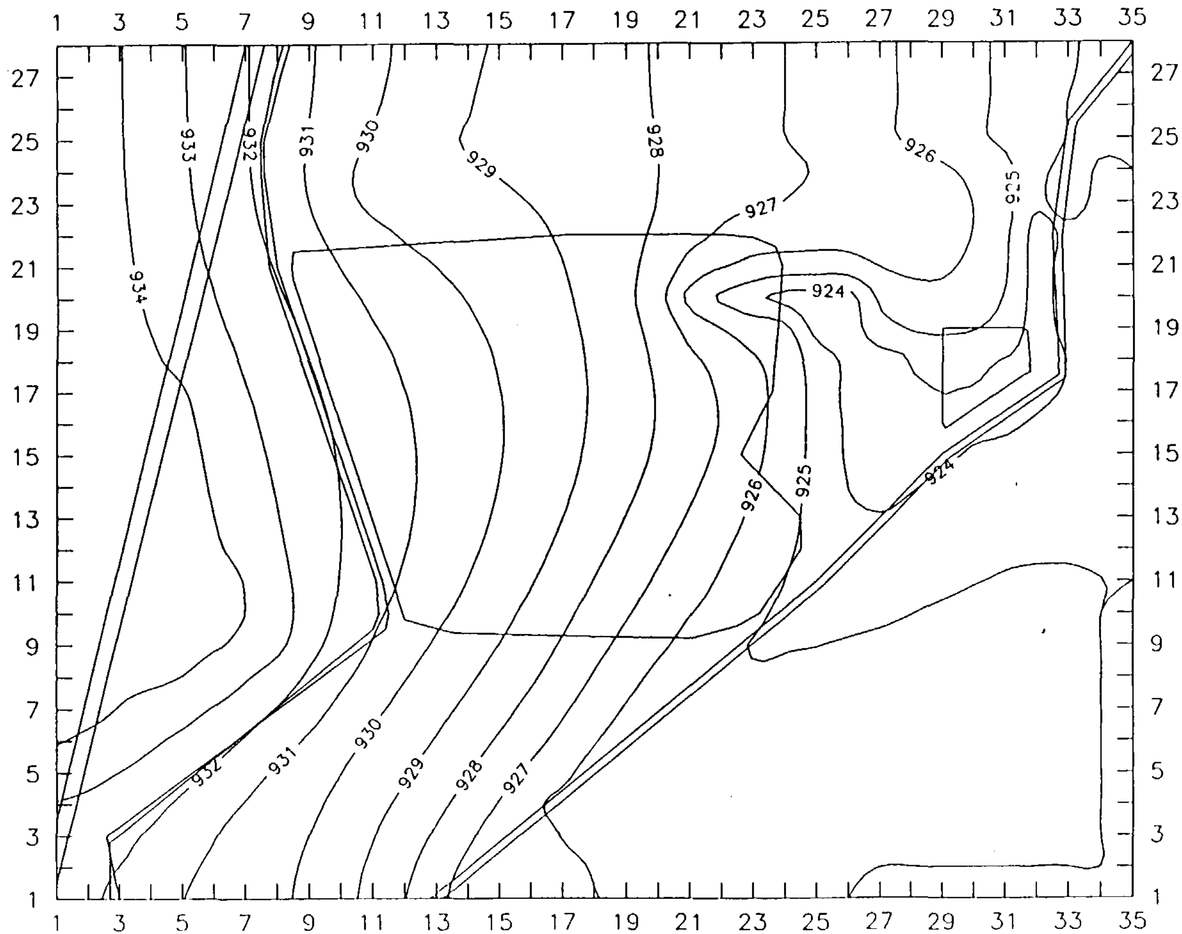
Layer 2



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         0          0                                              IAPART,ISTRT
         1          1  (28I2)                              3       IBOUND-1
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   365.25        1        1       PERLEN,NSTP,TSMULT      T-1
   365.25        1        1       PERLEN,NSTP,TSMULT      T-2
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         0         0                   SS if ISS=1,    IBCFBD            BCF.WS4
1 3
        11         1. (2F5.0)                            TRPY
 1.0  1.0
         0        100.                                                  DELR
         0        100.                                                  DELC
         0        0.25                                                  SF1-1
        11         1.   (28F2.0)                     3                  Hy-1
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         0        920.                                                  Bot-1
         0         0.4                                                  Vcont-1
         0        0.25                                                  SF1-2
        11         1.   (25F3.0)                     8                  Trans-2
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0	0.25	SF2-2
0	920.	Top-2

29	0				DFN.WS4
29	Lay Row	Col	Elev.	Cond	
1	5	1	929.5	5000.0	
1	5	2	929.5	5000.0	
1	6	3	929.5	5000.0	
1	7	4	929.5	5000.0	
1	8	5	929.5	4000.0	
1	9	5	929.5	5000.0	
1	10	6	929.5	4000.0	
1	11	6	929.5	5000.0	
1	11	7	929.5	4000.0	
1	12	7	929.5	5000.0	
1	12	8	929.5	5000.0	
1	13	8	929.5	5000.0	
1	13	9	929.5	5000.0	
1	14	9	929.5	5000.0	
1	15	9	929.5	5000.0	
1	10	23	928.0	5000.0	
1	10	24	928.0	5000.0	
1	11	23	928.0	5000.0	
1	11	24	928.0	5000.0	
1	12	23	928.0	5000.0	
1	12	24	928.0	5000.0	
1	13	23	928.0	5000.0	
1	13	24	928.0	5000.0	
1	13	25	928.0	5000.0	
1	14	25	928.0	5000.0	
1	15	25	928.0	5000.0	
1	15	26	928.0	5000.0	
1	15	27	928.0	5000.0	
1	16	26	928.0	5000.0	
-1					T-2
-1					T-3

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         1          0                                                     RCH.WS4
         1                                                           T-1
        18   0.00157  (28F2.0)                        0              6"/year
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        -1                                                           T-2
        -1                                                           T-3
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49	0					RIV.WS4
49	Lay Row	Col	Stage	Cond	RBot	
1	13	1	923.5	5000.	920.0	
1	14	2	923.5	5000.	920.0	
1	15	3	923.5	5000.	920.0	
1	16	4	923.5	5000.	920.0	
1	17	4	923.5	5000.	920.0	
1	18	5	923.5	5000.	920.0	
1	19	6	923.5	5000.	920.0	
1	20	7	923.5	5000.	920.0	
1	21	8	923.5	5000.	920.0	
1	22	8	923.5	5000.	920.0	
1	23	9	923.5	5000.	920.0	
1	24	10	923.5	5000.	920.0	
1	25	11	923.5	5000.	920.0	
1	26	12	923.5	5000.	920.0	
1	26	13	923.5	5000.	920.0	
1	26	14	923.5	5000.	920.0	
1	26	15	923.5	5000.	920.0	
1	26	16	923.5	5000.	920.0	
1	26	17	923.5	5000.	920.0	
1	26	18	923.5	5000.	920.0	
1	26	19	923.5	5000.	920.0	
1	26	20	923.5	5000.	920.0	
1	25	19	923.5	5000.	920.0	
1	25	20	923.5	5000.	920.0	
1	24	20	923.5	5000.	920.0	
1	23	20	923.5	5000.	920.0	
1	22	20	923.5	5000.	920.0	
1	21	20	923.5	5000.	920.0	
1	27	13	923.5	5000.	920.0	
1	27	14	923.5	5000.	920.0	
1	27	15	923.5	5000.	920.0	
1	27	16	923.5	5000.	920.0	
1	27	17	923.5	5000.	920.0	
1	27	18	923.5	5000.	920.0	
1	28	14	923.5	5000.	920.0	
1	29	15	923.5	5000.	920.0	
1	30	16	923.5	5000.	920.0	
1	31	16	923.5	5000.	920.0	
1	32	17	923.5	5000.	920.0	
1	32	18	923.5	5000.	920.0	
1	32	19	923.5	5000.	920.0	
1	32	20	923.5	5000.	920.0	
1	32	21	923.5	5000.	920.0	
1	32	22	923.5	5000.	920.0	
1	33	23	923.5	5000.	920.0	
1	33	24	923.5	5000.	920.0	
1	33	25	923.5	5000.	920.0	
1	33	26	923.5	5000.	920.0	
1	34	27	923.5	5000.	920.0	
-1						T-2
-1						T-3

100	10		SIF.WS4
1.0	0.005	1	

4	4	0	0	IHEDFM,IDDNFM,IHEDLN,IDDNLN	WS4
0	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T1
1	0	1	0	hdpr,ddpr,hdsv,ddsv	L-1
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T2
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T3
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T4
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T5
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T6
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T7
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T8
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T9
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T10
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T11
-1	1	0	1	INCODE,IHDDFL,IBUDFL,ICBCFL	T12

```
.RM140/U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER MODEL
BAS.WS4  - Woodstock Landfill, 2 layer flow model                         Flow calibrated by discharge, with RI Report
Dat
  2 LAYERS        35 ROWS        28 COLUMNS
  1 STRESS PERIOD(S) IN SIMULATION

MODEL TIME UNIT IS DAYS
I/O UNITS:
ELEMENT OF IUNIT:  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
        I/O UNIT: 11  0 13 14  0  0  0 18 19  0  0 22  0  0  0  0  0  0  0  0  0  0  0  0

BAS1 -- BASIC MODEL PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT  1
ARRAYS RHS AND BUFF WILL SHARE MEMORY.
START HEAD WILL NOT BE SAVED -- DRAWDOWN CANNOT BE CALCULATED
   16731 ELEMENTS IN X ARRAY ARE USED BY BAS
   16731 ELEMENTS OF X ARRAY USED OUT OF  800000

BCF1 -- BLOCK-CENTERED FLOW PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 11
TRANSIENT SIMULATION
     LAYER  AQUIFER TYPE
     ------------------
        1        1
        2        3
    7842 ELEMENTS IN X ARRAY ARE USED BY BCF
   24573 ELEMENTS OF X ARRAY USED OUT OF  800000

DRN1 -- DRAIN PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 13
MAXIMUM OF   29 DRAINS
     145 ELEMENTS IN X ARRAY ARE USED FOR DRAINS
   24718 ELEMENTS OF X ARRAY USED OUT OF  800000

RCH1 -- RECHARGE PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 18
OPTION 1 -- RECHARGE TO TOP LAYER
     980 ELEMENTS OF X ARRAY USED FOR RECHARGE
   25698 ELEMENTS OF X ARRAY USED OUT OF  800000

RIV1 -- RIVER PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 14
MAXIMUM OF   49 RIVER NODES
     294 ELEMENTS IN X ARRAY ARE USED FOR RIVERS
   25992 ELEMENTS OF X ARRAY USED OUT OF  800000

SIP1 -- STRONGLY IMPLICIT PROCEDURE SOLUTION PACKAGE, VERSION 1, 9/1/87 INPUT READ FROM UNIT 19
MAXIMUM OF 100 ITERATIONS ALLOWED FOR CLOSURE
10 ITERATION PARAMETERS
    8250 ELEMENTS IN X ARRAY ARE USED BY SIP
   34242 ELEMENTS OF X ARRAY USED OUT OF  800000

BAS.WS4  - Woodstock Landfill, 2 layer flow model                         Flow calibrated by discharge, with RI Report
Dat


                              BOUNDARY ARRAY FOR LAYER  1 WILL BE READ ON UNIT  1 USING FORMAT:   (28I2)
                       ------------------------------------------------------------------------------------------

       1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
..........................................................................................
 1     1  1  1  1  1  1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1
```

2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	-3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	-3	-3	-3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	-3	-3	-3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	-3	-3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	5	5	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	5	1	1	3	3	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5	1	1	3	3	1	1	1	1
12	1	1	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	3	3	1	1	1	1
13	1	1	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	3	3	3	1	1	1
14	1	1	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	3	3	1	1
15	2	1	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	3	3	1	1
16	1	2	1	1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	1	3	1	1
17	1	1	2	1	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1	1	1
18	1	1	1	2	1	1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1	1	1
19	1	1	1	1	2	1	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1	1	1
20	1	1	1	1	1	2	1	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1	1	1
21	0	1	1	1	1	1	2	1	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1	1	1
22	0	1	1	1	1	1	1	2	1	5	5	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1	1	1
23	0	1	1	1	1	1	1	1	2	1	5	5	5	5	5	5	5	5	5	1	1	1	1	1	1	1	1	1
24	0	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	0	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1
27	0	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	0	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	0	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1
30	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
31	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1
32	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	1	1	1	1
33	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
34	0	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	0	0	0	0	0	0	0	0	0	0	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

BOUNDARY ARRAY FOR LAYER 2 WILL BE READ ON UNIT 1 USING FORMAT: (28I2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	2	2	2	2	2	2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
18	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
19	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
20	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
21	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
22	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
23	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
24	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
25	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
26	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
27	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
28	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
29	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	-2	2	2
30	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
31	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
32	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
33	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
34	0	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
35	0	0	0	0	0	0	0	0	0	0	2	2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

AQUIFER HEAD WILL BE SET TO 926.00 AT ALL NO-FLOW NODES (IBOUND=0).

INITIAL HEAD FOR LAYER 1 WILL BE READ ON UNIT 1 USING FORMAT: (15F5.1)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	16	17	18	19	20	21	22	23	24	25	26	27	28		
1	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00		
2	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00		
3	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00		
4	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00		
5	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
6	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	935.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
7	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	935.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
8	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
9	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
10	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
11	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
12	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
13	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		

14	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
15	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
16	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
17	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
18	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
19	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
20	924.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
21	924.10	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
22	924.30	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
23	924.40	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
24	924.50	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
25	924.70	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
26	924.80	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
27	924.90	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
28	925.10	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
29	925.20	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
30	925.30	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
31	925.50	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
32	925.60	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	930.00	930.00	930.00	930.00
33	925.70	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	923.00	923.00	923.00
34	925.90	926.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
35	926.00	925.90	925.70	925.60	925.50	925.40	925.20	925.10	925.00	924.90	924.70	924.60	924.50	924.40	924.20	924.10	924.00	924.00	924.00	924.00	924.00	924.00	924.00	924.00	923.50	923.50	923.50	923.50

INITIAL HEAD FOR LAYER 2 WILL BE READ ON UNIT 1 USING FORMAT: (15F5.1)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
2	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00

3	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00		
4	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00		
5	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
6	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	935.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
7	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	935.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
8	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	935.00	935.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
9	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
10	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
11	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
12	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
13	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
14	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
15	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
16	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
17	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
18	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
19	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
20	924.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
21	924.10	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
22	924.30	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
23	924.40	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
24	924.50	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
25	924.70	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
26	924.80	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
27	924.90	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
28	925.10	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
29	925.20	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
30	925.30	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
31	925.50	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	923.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		

32	925.60	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	923.00	923.00	923.00	923.00	923.00	923.00	923.00	930.00	930.00	930.00	930.00		
33	925.70	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	923.00	923.00	923.00	923.00		
34	925.90	930.00	933.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00
	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00	930.00		
35	926.00	925.90	925.70	925.60	925.50	925.40	925.20	925.10	925.00	924.90	924.70	924.60	924.50	924.40	924.20
	924.10	924.00	924.00	924.00	924.00	924.00	924.00	924.00	924.00	923.50	923.50	923.50	923.50		

HEAD PRINT FORMAT IS FORMAT NUMBER 4 DRAWDOWN PRINT FORMAT IS FORMAT NUMBER 4
HEADS WILL BE SAVED ON UNIT 0 DRAWDOWNS WILL BE SAVED ON UNIT 0
OUTPUT CONTROL IS SPECIFIED EVERY TIME STEP

COLUMN TO ROW ANISOTROPY WILL BE READ ON UNIT 11 USING FORMAT: (2F5.0)

1.0000 1.0000

DELR = 100.0000
DELC = 100.0000
PRIMARY STORAGE COEF = 0.2500000 FOR LAYER 1

HYD. COND. ALONG ROWS FOR LAYER 1 WILL BE READ ON UNIT 11 USING FORMAT: (26F2.0)
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	1 16	2 17	3 18	4 19	5 20	6 21	7 22	8 23	9 24	10 25	11 26	12 27	13 28	14	15
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
11	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
12	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
13	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0

	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
14	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
15	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
16	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
17	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
18	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
19	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
21	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
22	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	10.0	10.0	10.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
23	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
24	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
25	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
26	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
27	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
28	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
29	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
30	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
31	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
32	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
33	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
34	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		
35	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0		

BOTTOM = 920.0000 FOR LAYER 1
VERT HYD COND /THICKNESS = 0.4000000 FOR LAYER 1
PRIMARY STORAGE COEF = 0.2500000 FOR LAYER 2

HYD. COND. ALONG ROWS FOR LAYER 2 WILL BE READ ON UNIT 11 USING FORMAT: (25F3.0)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28												

....

...

1	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
2	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
3	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
4	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
5	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
6	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
7	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
8	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
9	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0												
10	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0												
11	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0												
12	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0												
13	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0												
14	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0												
15	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0												
16	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0												
17	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
	15.0	15.0	15.0	10.0	10.0	10.0	10.0	10.0												
18	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
	15.0	15.0	15.0	5.0	5.0	5.0	5.0	5.0												
19	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	10.0	10.0	5.0	2.0	2.0	2.0	2.0	2.0												
20	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	10.0	5.0	2.0	1.0	1.0	0.1	0.1	0.1												
21	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
	5.0	1.0	0.1	0.1	0.1	0.1	0.1	0.1												
22	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0
	5.0	1.0	0.1	0.1	0.1	0.1	0.1	0.1												
23	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.0	6.0	5.0	5.0	5.0	5.0	5.0
	3.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1												
24	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	5.0	5.0	3.0	3.0
	3.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1												
25	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	5.0	3.0	3.0	3.0
	1.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1												
26	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	5.0	3.0	3.0	3.0	3.0
	1.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1												
27	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	3.0	3.0	3.0	3.0	1.0
	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1												
28	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	5.0	5.0	5.0	3.0	3.0	3.0	3.0	1.0
	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1												

```
29  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0   5.0   5.0   5.0   3.0   3.0   3.0   1.0   0.1
     0.1   0.1   0.1   0.1   0.1   0.1   0.1   0.1
30  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0   5.0   5.0   5.0   3.0   3.0   3.0   1.0   0.1
     0.1   0.1   0.1   0.1   0.1   0.1   0.1   0.1
31  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0   5.0   5.0   5.0   3.0   3.0   1.0   0.1   0.1
     0.1   0.1   0.1   0.1   0.1   0.1   0.1   0.1
32  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0   5.0   5.0   5.0   3.0   3.0   1.0   0.1   0.1
     0.1   0.1   0.1   0.1   0.1   0.1   0.1   0.1
33  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0   5.0   5.0   5.0   3.0   3.0   1.0   0.1   0.1
     0.1   0.1   0.1   0.1   0.1   0.1   0.1   0.1
34  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0   5.0   5.0   5.0   3.0   3.0   1.0   0.1   0.1
     0.1   0.1   0.1   0.1   0.1   0.1   0.1   0.1
35  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0  10.0   5.0   5.0   5.0   3.0   3.0   1.0   0.1   0.1
     0.1   0.1   0.1   0.1   0.1   0.1   0.1   0.1
```

```
                  BOTTOM =   900.0000     FOR LAYER  2
SECONDARY STORAGE COEF =  0.2500000     FOR LAYER  2
                     TOP =   920.0000     FOR LAYER  2
```

```
                 SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE
                 -------------------------------------------
 MAXIMUM ITERATIONS ALLOWED FOR CLOSURE =       100
                 ACCELERATION PARAMETER =     1.0000
      HEAD CHANGE CRITERION FOR CLOSURE =    0.50000E-02
      SIP HEAD CHANGE PRINTOUT INTERVAL =       999
      CALCULATE ITERATION PARAMETERS FROM MODEL CALCULATED WSEED
     STRESS PERIOD NO.   1, LENGTH =   365.2500
     ----------------------------------------------

     NUMBER OF TIME STEPS =      1

      MULTIPLIER FOR DELT =     1.000

   INITIAL TIME STEP SIZE =   365.2500
```

29 DRAINS

LAYER	ROW	COL	ELEVATION	CONDUCTANCE	DRAIN NO.
1	5	1	929.5	5000.	1
1	5	2	929.5	5000.	2
1	6	3	929.5	5000.	3
1	7	4	929.5	5000.	4
1	8	5	929.5	4000.	5
1	9	5	929.5	5000.	6
1	10	6	929.5	4000.	7
1	11	6	929.5	5000.	8
1	11	7	929.5	4000.	9
1	12	7	929.5	5000.	10
1	12	8	929.5	5000.	11
1	13	8	929.5	5000.	12
1	13	9	929.5	5000.	13
1	14	9	929.5	5000.	14
1	15	9	929.5	5000.	15
1	10	23	928.0	5000.	16

1	10	24	928.0	5000.	17
1	11	23	928.0	5000.	18
1	11	24	928.0	5000.	19
1	12	23	928.0	5000.	20
1	12	24	928.0	5000.	21
1	13	23	929.0	5000.	22
1	13	24	928.0	5000.	23
1	13	25	928.0	5000.	24
1	14	25	928.0	5000.	25
1	15	25	928.0	5000.	26
1	15	26	929.0	5000.	27
1	15	27	928.0	5000.	28
1	16	26	929.0	5000.	29

RECHARGE WILL BE READ ON UNIT 18 USING FORMAT: (28F2.0)

	1 11 21	2 12 22	3 13 23	4 14 24	5 15 25	6 16 26	7 17 27	8 18 28	9 19	10 20
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03	1.5700E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	1.5700E-03	1.5700E-03	1.5700E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03

	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	1.5700E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03	1.5700E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03	1.5700E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03	1.5700E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03
	1.5700E-03	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	3.1400E-03	1.5700E-03	1.5700E-03	1.5700E-03	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5700E-03
	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	1.5700E-03	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
24	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
25	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
26	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
27	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
28	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
29	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
30	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		

32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
33	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
34	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
35	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		

49 RIVER REACHES

LAYER	ROW	COL	STAGE	CONDUCTANCE	BOTTOM ELEVATION	RIVER REACH
1	13	1	923.5	5000.	920.0	1
1	14	2	923.5	5000.	920.0	2
1	15	3	923.5	5000.	920.0	3
1	16	4	923.5	5000.	920.0	4
1	17	4	923.5	5000.	920.0	5
1	18	5	923.5	5000.	920.0	6
1	19	6	923.5	5000.	920.0	7
1	20	7	923.5	5000.	920.0	8
1	21	8	923.5	5000.	920.0	9
1	22	8	923.5	5000.	920.0	10
1	23	9	923.5	5000.	920.0	11
1	24	10	923.5	5000.	920.0	12
1	25	11	923.5	5000.	920.0	13
1	26	12	923.5	5000.	920.0	14
1	26	13	923.5	5000.	920.0	15
1	26	14	923.5	5000.	920.0	16
1	26	15	923.5	5000.	920.0	17
1	26	16	923.5	5000.	920.0	18
1	26	17	923.5	5000.	920.0	19
1	26	18	923.5	5000.	920.0	20
1	26	19	923.5	5000.	920.0	21
1	26	20	923.5	5000.	920.0	22
1	25	19	923.5	5000.	920.0	23
1	25	20	923.5	5000.	920.0	24
1	24	20	923.5	5000.	920.0	25
1	23	20	923.5	5000.	920.0	26
1	22	20	923.5	5000.	920.0	27
1	21	20	923.5	5000.	920.0	28
1	27	13	923.5	5000.	920.0	29
1	27	14	923.5	5000.	920.0	30
1	27	15	923.5	5000.	920.0	31
1	27	16	923.5	5000.	920.0	32
1	27	17	923.5	5000.	920.0	33
1	27	18	923.5	5000.	920.0	34
1	28	14	923.5	5000.	920.0	35
1	29	15	923.5	5000.	920.0	36
1	30	16	923.5	5000.	920.0	37
1	31	16	923.5	5000.	920.0	38
1	32	17	923.5	5000.	920.0	39
1	32	18	923.5	5000.	920.0	40
1	32	19	923.5	5000.	920.0	41

```
                  1      32     20    923.5         5000.              920.0           42
                  1      32     21    923.5         5000.              920.0           43
                  1      32     22    923.5         5000.              920.0           44
                  1      33     23    923.5         5000.              920.0           45
                  1      33     24    923.5         5000.              920.0           46
                  1      33     25    923.5         5000.              920.0           47
                  1      33     26    923.5         5000.              920.0           48
                  1      34     27    923.5         5000.              920.0           49

AVERAGE SEED = 0.00014291
MINIMUM SEED = 0.00000201

  10 ITERATION PARAMETERS CALCULATED FROM AVERAGE SEED:

          0.0000000E+00  0.6260759E+00  0.8601807E+00  0.9477182E+00  0.9804506E+00  0.9926930E+00
          0.9972666E+00  0.9989779E+00  0.9996178E+00  0.9998571E+00

   74 ITERATIONS FOR TIME STEP   1 IN STRESS PERIOD  1
MAXIMUM HEAD CHANGE FOR EACH ITERATION:
 HEAD CHANGE LAYER,ROW,COL HEAD CHANGE LAYER,ROW,COL HEAD CHANGE LAYER,ROW,COL HEAD CHANGE LAYER,ROW,COL HEAD CHANGE LAYER,RO
W,COL
------------------------------------------------------------------------------------------------------------------------------
-------
  -6.463      (  1, 33, 24)  -1.587      (  2, 34, 26)  -1.948      (  1, 17,  1) -0.4326      (  1, 22, 18) -0.9176      (  2, 24
,  3)
 -0.2888      (  1, 22, 16) -0.3285      (  2, 30,  6)  0.6586      (  2, 33,  2) -0.5751      (  2, 34,  3)   2.396      (  2, 34
,  3)
  -1.578      (  2, 34,  3) -0.2338      (  2, 32,  3) -0.6800      (  1, 32,  3) -0.1021      (  1, 31,  4) -0.3957      (  2, 31
,  4)
  0.1336      (  2, 33,  2) -0.1393      (  2, 34,  3)  0.3620      (  2, 34,  3) -0.3376      (  2, 34,  3)   1.408      (  2, 34
,  3)
 -0.9327      (  2, 34,  3) -0.1373      (  2, 32,  3) -0.4002      (  1, 32,  3) -0.5923E-01 (  1, 31,  4) -0.2307      (  2, 31
,  4)
  0.7845E-01 (  2, 33,  2) -0.8109E-01 (  2, 34,  3)  0.2111      (  2, 34,  3) -0.1970      (  2, 34,  3)  0.8217      (  2, 34
,  3)
  0.5465      (  2, 34,  3) -0.8015E-01 (  2, 32,  3) -0.2338      (  1, 32,  3) -0.3429E-01 (  1, 31,  4) -0.1341      (  2, 31
,  4)
  0.4574E-01 (  2, 33,  2) -0.4707E-01 (  2, 34,  3)  0.1227      (  2, 34,  3) -0.1145      (  2, 34,  3)  0.4777      (  2, 34
,  3)
 -0.3184      (  2, 34,  3) -0.4658E-01 (  2, 32,  3) -0.1360      (  1, 32,  3) -0.1984E-01 (  1, 31,  4) -0.7770E-01 (  2, 31
,  4)
  0.2657E-01 (  2, 33,  2) -0.2727E-01 (  2, 34,  3)  0.7111E-01 (  2, 34,  3) -0.6642E-01 (  2, 34,  3)  0.2770      (  2, 34
,  3)
 -0.1848      (  2, 34,  3) -0.2701E-01 (  2, 32,  3) -0.7889E-01 (  1, 32,  3) -0.1147E-01 (  1, 31,  4) -0.4498E-01 (  2, 31
,  4)
  0.1540E-01 (  2, 33,  2) -0.1578E-01 (  2, 34,  3)  0.4116E-01 (  2, 34,  3) -0.3846E-01 (  2, 34,  3)  0.1604      (  2, 34
,  3)
 -0.1071      (  2, 34,  3) -0.1564E-01 (  2, 32,  3) -0.4569E-01 (  1, 32,  3) -0.6630E-02 (  1, 31,  4) -0.2602E-01 (  2, 31
,  4)
  0.8914E-02 (  2, 33,  2) -0.9126E-02 (  2, 34,  3)  0.2381E-01 (  2, 34,  3) -0.2225E-01 (  2, 34,  3)  0.9278E-01 (  2, 34
,  3)
 -0.6199E-01 (  2, 34,  3) -0.9047E-02 (  2, 32,  3) -0.2643E-01 (  1, 32,  3) -0.3832E-02 (  1, 31,  4)

HEAD/DRAWDOWN PRINTOUT FLAG = 1     TOTAL BUDGET PRINTOUT FLAG = 0     CELL-BY-CELL FLOW TERM FLAG = 1
OUTPUT FLAGS FOR ALL LAYERS ARE THE SAME:
  HEAD    DRAWDOWN  HEAD  DRAWDOWN
PRINTOUT  PRINTOUT  SAVE    SAVE
----------------------------------
```

1 0 1 0

HEAD IN LAYER 1 AT END OF TIME STEP 1 IN STRESS PERIOD 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	16	17	18	19	20	21	22	23	24	25	26	27	28		
1	931.90	932.05	932.33	932.75	933.30	934.02	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00		
2	931.69	931.84	932.13	932.56	933.10	933.73	934.38	934.72	934.87	934.93	934.96	934.97	934.97	934.96	934.94
	934.90	934.85	934.77	934.69	934.62	934.56	934.51	934.48	934.45	934.44	934.43	934.42	934.42		
3	931.25	931.42	931.75	932.20	932.77	933.40	934.06	934.61	934.82	934.91	934.94	934.95	934.95	934.93	934.89
	934.83	934.71	934.53	934.35	934.21	934.09	934.00	933.94	933.89	933.86	933.84	933.83	933.82		
4	930.56	930.73	931.15	931.67	932.29	933.01	933.83	935.00	934.88	934.93	934.95	934.95	934.93	934.91	934.87
	934.80	934.64	934.28	933.98	933.75	933.58	933.45	933.35	933.28	933.24	933.21	933.20	933.19		
5	929.60	929.65	930.46	931.09	931.79	932.58	933.52	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	933.94	933.50	933.21	932.99	932.82	932.69	932.60	932.55	932.52	932.51	932.51		
6	929.59	929.67	929.63	930.47	931.22	932.07	933.01	934.03	935.00	935.00	935.00	934.59	934.38	934.24	934.12
	933.98	933.76	933.34	932.97	932.67	932.42	932.21	932.05	931.95	931.90	931.88	931.88	931.88		
7	929.37	929.45	929.58	929.63	930.59	931.50	932.48	933.56	935.00	935.00	935.00	934.20	933.87	933.65	933.48
	933.30	933.06	932.75	932.44	932.14	931.86	931.60	931.40	931.29	931.26	931.27	931.29	931.31		
8	929.07	929.15	929.32	929.55	929.68	930.89	931.89	933.02	935.00	935.00	934.05	933.61	933.32	933.11	932.92
	932.73	932.51	932.23	931.94	931.64	931.31	930.98	930.70	930.58	930.61	930.67	930.74	930.77		
9	928.65	928.76	928.96	929.24	929.54	930.35	931.20	932.10	932.95	933.25	933.14	932.95	932.77	932.60	932.44
	932.26	932.05	931.78	931.51	931.20	930.81	930.32	929.85	929.73	929.92	930.10	930.22	930.28		
10	928.04	928.20	928.46	928.80	929.20	929.58	930.44	931.19	931.83	932.19	932.30	932.28	932.21	932.11	931.98
	931.84	931.66	931.45	931.17	930.83	930.32	929.61	928.23	928.20	929.18	929.54	929.73	929.82		
11	927.17	927.42	927.80	928.23	928.70	929.18	929.57	930.34	930.93	931.34	931.57	931.68	931.70	931.68	931.63
	931.52	931.35	931.14	930.86	930.50	929.95	929.22	928.12	928.09	928.73	929.09	929.30	929.39		
12	925.98	926.45	927.01	927.59	928.15	928.68	929.18	929.55	930.22	930.71	931.03	931.20	931.33	931.37	931.34
	931.25	931.10	930.90	930.62	930.26	929.71	929.03	928.09	928.05	928.45	928.75	928.95	929.05		
13	923.81	925.28	926.14	926.89	927.57	928.19	928.75	929.23	929.56	930.24	930.65	930.88	931.02	931.09	931.08
	931.01	930.88	930.69	930.42	930.08	929.58	928.97	928.10	928.04	928.06	928.48	928.68	928.78		
14	924.29	923.75	925.15	926.09	926.93	927.66	928.30	928.86	929.37	929.90	930.33	930.58	930.74	930.83	930.84
	930.78	930.67	930.49	930.25	929.95	929.52	929.05	928.59	928.32	928.04	928.29	928.43	928.56		
15	924.41	924.31	923.74	925.16	926.22	927.09	927.83	928.46	929.04	929.58	930.03	930.30	930.48	930.58	930.60
	930.56	930.45	930.29	930.08	929.81	929.48	929.11	928.76	928.46	928.05	928.03	928.06	928.39		
16	924.77	924.54	924.31	923.71	925.44	926.47	927.30	928.02	928.65	929.24	929.73	930.01	930.21	930.32	930.35
	930.32	930.21	930.06	929.86	929.64	929.39	929.11	928.86	928.62	928.36	928.05	928.31	928.45		
17	925.13	924.93	924.49	923.66	924.81	925.80	926.70	927.49	928.21	928.86	929.40	929.71	929.92	930.05	930.09
	930.05	929.93	929.76	929.56	929.38	929.22	929.05	928.93	928.78	928.61	928.50	928.55	928.61		
18	925.48	925.32	924.97	924.40	923.69	925.03	926.04	926.94	927.75	928.48	929.07	929.41	929.65	929.78	929.82
	929.77	929.62	929.41	929.18	929.00	928.95	928.93	928.93	928.92	928.86	928.80	928.81	928.83		
19	925.87	925.78	925.52	925.09	924.47	923.68	925.13	926.20	927.16	928.01	928.69	929.06	929.33	929.48	929.52
	929.44	929.24	928.92	928.57	928.31	928.44	928.68	928.89	929.07	929.13	929.10	929.11	929.12		
20	926.13	926.21	926.06	925.74	925.23	924.53	923.67	925.16	926.38	927.39	928.19	928.63	928.94	929.12	929.15
	929.04	928.76	928.29	927.65	926.99	927.56	928.25	928.82	929.22	929.40	929.59	929.64	929.66		
21	926.00	926.61	926.52	926.27	925.85	925.26	924.40	923.66	925.54	926.72	927.63	928.15	928.51	928.74	928.79
	928.65	928.29	927.65	926.51	923.83	926.06	927.66	929.04	929.54	929.72	929.82	929.86	929.87		
22	926.00	926.96	926.92	926.72	926.37	925.83	925.05	923.64	924.90	926.01	927.01	927.60	928.05	928.36	928.43
	928.31	927.94	927.32	926.10	923.63	925.44	927.34	929.10	929.66	929.84	929.92	929.94	929.95		
23	926.00	927.28	927.26	927.11	926.82	926.37	925.73	924.86	923.67	925.06	926.03	926.74	927.33	927.69	927.83
	927.75	927.43	926.82	925.65	923.58	925.21	928.18	929.34	929.75	929.90	929.95	929.97	929.98		
24	926.00	927.55	927.57	927.46	927.22	926.86	926.34	925.68	924.87	923.67	924.95	925.70	926.35	926.67	926.81
	926.75	926.56	926.14	925.12	923.56	925.31	928.42	929.45	929.80	929.92	929.97	929.98	929.99		

25	926.00	927.79	927.83	927.75	927.57	927.28	926.87	926.34	925.68	924.86	923.66	924.67	925.13	925.38	925.48
	925.48	925.46	925.06	923.55	923.53	925.84	928.61	929.52	929.83	929.94	929.97	929.99	929.99		
26	926.00	928.01	928.06	928.01	927.87	927.63	927.31	926.88	926.35	925.68	924.85	923.62	923.55	923.55	923.56
	923.56	923.55	923.54	923.54	923.55	926.23	928.81	929.60	929.86	929.95	929.98	929.99	929.99		
27	926.00	928.28	928.28	928.22	928.11	927.93	927.67	927.33	926.90	926.37	925.73	924.95	923.56	923.52	923.53
	923.53	923.54	923.56	925.00	925.93	928.17	929.29	929.73	929.89	929.95	929.98	929.98	929.99		
28	926.00	928.44	928.42	928.38	928.29	928.15	927.95	927.68	927.34	926.93	926.44	925.89	925.02	923.56	924.02
	924.56	925.04	925.50	926.18	927.22	928.88	929.53	929.79	929.89	929.94	929.96	929.97	929.97		
29	926.00	928.50	928.50	928.48	928.42	928.32	928.17	927.96	927.69	927.36	926.99	926.58	925.97	924.95	923.57
	924.57	925.48	926.16	927.06	928.49	929.26	929.59	929.74	929.82	929.88	929.91	929.92	929.93		
30	926.00	928.47	928.49	928.50	928.48	928.42	928.31	928.15	927.93	927.66	927.36	927.05	926.59	925.82	924.89
	923.55	925.17	926.22	927.37	928.66	929.15	929.35	929.47	929.57	929.69	929.76	929.80	929.82		
31	926.00	928.32	928.38	928.45	928.[illegible]	928.48	928.40	928.27	928.08	927.95	927.58	927.31	926.94	926.32	925.47
	923.57	924.30	925.64	927.34	927.99	928.23	928.36	928.52	928.74	929.18	929.37	929.46	929.50		
32	926.00	927.99	928.15	928.33	928.44	928.48	928.44	928.34	928.16	927.92	927.64	927.37	927.04	926.55	925.97
	925.06	923.57	923.52	923.51	923.51	923.51	923.51	924.65	925.38	927.79	928.27	928.48	928.60		
33	926.00	927.37	927.79	928.15	928.37	928.46	928.45	928.36	928.17	927.89	927.53	927.20	926.83	926.41	926.05
	925.71	925.33	925.84	927.32	927.69	927.66	927.13	923.53	923.52	923.51	923.51	924.63	925.34		
34	926.00	926.00	927.36	927.98	928.30	928.44	928.45	928.36	928.15	927.80	927.22	926.77	926.15	925.76	925.51
	925.42	925.35	925.93	927.37	927.74	927.77	927.57	927.02	926.88	926.72	926.30	923.53	926.49		
35	926.00	926.00	926.00	926.00	926.00	926.00	926.00	926.00	926.00	926.00	926.59	926.09	924.50	924.40	924.20
	924.10	924.00	924.00	924.00	924.00	924.00	924.00	924.00	924.00	923.50	923.50	923.50	923.50		

HEAD IN LAYER 2 AT END OF TIME STEP 1 IN STRESS PERIOD 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	16	17	18	19	20	21	22	23	24	25	26	27	28		
...															
1	931.90	932.04	932.32	932.74	933.30	934.02	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00
	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00	935.00		
2	931.68	931.83	932.13	932.56	933.10	933.73	934.38	934.72	934.87	934.93	934.96	934.97	934.97	934.96	934.94
	934.90	934.85	934.77	934.69	934.61	934.56	934.51	934.48	934.45	934.44	934.43	934.42	934.42		
3	931.25	931.41	931.74	932.20	932.76	933.40	934.06	934.61	934.82	934.91	934.94	934.95	934.95	934.93	934.89
	934.83	934.71	934.53	934.35	934.21	934.09	934.00	933.93	933.89	933.85	933.83	933.82	933.82		
4	930.56	930.74	931.15	931.68	932.30	933.01	933.84	934.82	934.88	934.93	934.95	934.95	934.93	934.91	934.87
	934.80	934.63	934.28	933.98	933.75	933.58	933.44	933.35	933.28	933.23	933.21	933.19	933.19		
5	929.72	929.84	930.46	931.09	931.79	932.59	933.53	934.75	934.95	934.99	934.98	934.95	934.92	934.90	934.89
	934.85	934.74	933.95	933.51	933.21	932.99	932.82	932.69	932.60	932.55	932.53	932.52	932.51		
6	929.59	929.67	929.79	930.47	931.22	932.07	933.01	934.03	934.89	934.98	934.94	934.60	934.38	934.25	934.13
	933.99	933.77	933.34	932.98	932.67	932.42	932.21	932.05	931.95	931.90	931.89	931.89	931.89		
7	929.37	929.45	929.58	929.79	930.59	931.50	932.48	933.57	934.81	934.94	934.83	934.20	933.87	933.66	933.43
	933.30	933.07	932.76	932.44	932.14	931.86	931.61	931.41	931.29	931.26	931.27	931.29	931.31		
8	929.06	929.15	929.32	929.55	929.86	930.90	931.89	933.02	934.58	934.70	934.05	933.61	933.32	933.11	932.93
	932.74	932.51	932.24	931.95	931.64	931.31	930.98	930.70	930.58	930.61	930.68	930.74	930.77		
9	928.65	928.76	928.96	929.24	929.59	930.35	931.21	932.10	932.95	933.26	933.14	932.95	932.77	932.61	932.44
	932.27	932.05	931.80	931.52	931.20	930.80	930.32	929.85	929.73	929.92	930.10	930.22	930.28		
10	928.04	928.19	928.46	928.80	929.20	929.66	930.44	931.19	931.83	932.19	932.30	932.29	932.22	932.12	931.99
	931.85	931.67	931.45	931.17	930.82	930.31	929.61	928.51	928.45	929.18	929.54	929.73	929.82		
11	927.17	927.42	927.79	928.23	928.70	929.17	929.64	930.34	930.93	931.34	931.58	931.68	931.71	931.69	931.63
	931.52	931.35	931.14	930.85	930.49	929.94	929.21	928.26	928.19	928.73	929.09	929.29	929.39		
12	925.97	926.44	927.01	927.58	928.15	928.68	929.18	929.62	930.22	930.71	931.03	931.21	931.32	931.36	931.33
	931.24	931.10	930.89	930.61	930.24	929.71	929.03	928.20	928.11	928.44	928.75	928.95	929.05		
13	924.19	925.27	926.13	926.88	927.57	928.19	928.74	929.23	929.63	930.24	930.64	930.88	931.02	931.08	931.08
	931.01	930.87	930.68	930.42	930.07	929.57	928.97	928.22	928.10	928.14	928.48	928.67	928.78		
14	924.28	924.05	925.14	926.08	926.92	927.66	928.30	928.86	929.37	929.90	930.32	930.58	930.74	930.82	930.83

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       930.78  930.66  930.49  930.25  929.94  929.52  929.05  928.59  928.32  928.09  928.29  928.43  928.56
 15    924.41  924.30  924.03  925.15  926.21  927.09  927.82  928.46  929.03  929.57  930.02  930.29  930.47  930.57  930.60
       930.55  930.45  930.28  930.07  929.81  929.47  929.11  928.76  928.46  928.10  929.07  928.13  928.39
 16    924.76  924.55  924.31  923.95  925.44  926.47  927.30  928.01  928.65  929.23  929.72  930.01  930.20  930.32  930.35
       930.31  930.21  930.05  929.86  929.64  929.38  929.11  928.86  928.61  928.36  928.11  928.31  928.44
 17    925.13  924.93  924.49  923.84  924.81  925.79  926.69  927.49  928.20  928.85  929.38  929.70  929.92  930.04  930.08
       930.04  929.93  929.76  929.56  929.37  929.21  929.05  928.92  928.78  928.61  928.50  928.55  928.60
 18    925.48  925.31  924.96  924.40  923.92  925.02  926.03  926.94  927.75  928.47  929.05  929.40  929.64  929.79  929.82
       929.76  929.62  929.40  929.17  929.00  928.94  928.93  928.93  928.92  928.85  928.80  928.81  928.83
 19    925.86  925.77  925.52  925.08  924.47  923.88  925.12  926.19  927.15  928.00  926.67  929.06  929.32  929.47  929.51
       929.43  929.23  928.92  928.57  928.31  928.44  928.68  928.89  929.06  929.12  929.10  929.11  929.11
 20    926.14  926.21  926.06  925.73  925.22  924.53  923.87  925.15  926.37  927.38  928.17  928.62  928.93  929.11  929.15
       929.03  928.75  928.29  927.64  926.98  927.55  928.25  928.82  929.22  929.40  929.59  929.64  929.66
 21    926.58  926.60  926.52  926.26  925.85  925.25  924.48  923.85  925.53  926.71  927.62  928.14  928.51  928.73  928.78
       928.64  928.28  927.65  926.50  924.15  926.05  927.66  929.04  929.54  929.72  929.82  929.86  929.87
 22    926.84  926.96  926.91  926.72  926.36  925.83  925.04  923.81  924.89  926.00  926.98  927.58  928.03  928.35  928.42
       928.30  927.93  927.31  926.09  923.76  925.43  927.34  929.10  929.66  929.84  929.92  929.94  929.95
 23    927.14  927.27  927.26  927.11  926.82  926.37  925.72  924.85  923.87  925.05  926.02  926.73  927.32  927.68  927.82
       927.74  927.43  926.82  925.64  923.67  925.20  928.18  929.34  929.75  929.90  929.95  929.97  929.98
 24    927.40  927.55  927.56  927.45  927.22  926.85  926.34  925.67  924.86  923.88  924.94  925.69  926.34  926.66  926.80
       926.75  926.55  926.13  925.11  923.62  925.30  928.42  929.45  929.80  929.92  929.97  929.98  929.99
 25    927.62  927.79  927.83  927.75  927.57  927.27  926.86  926.33  925.67  924.85  923.85  924.66  925.12  925.37  925.47
       925.47  925.46  925.05  923.61  923.56  925.83  928.61  929.52  929.83  929.94  929.97  929.99  929.99
 26    927.76  928.01  928.06  928.01  927.86  927.63  927.30  926.88  926.34  925.67  924.84  923.77  923.61  923.61  923.61
       923.61  923.59  923.57  923.57  923.60  926.22  928.81  929.61  929.86  929.95  929.98  929.99  929.99
 27    926.00  928.28  928.27  928.22  928.11  927.92  927.66  927.32  926.89  926.36  925.72  924.95  923.63  923.54  923.55
       923.56  923.57  923.62  924.99  925.92  928.17  929.30  929.73  929.89  929.95  929.98  929.98  929.99
 28    926.00  928.43  928.42  928.38  928.29  928.15  927.95  927.68  927.34  926.93  926.44  925.88  925.02  923.63  924.01
       924.55  925.04  925.49  926.17  927.21  928.88  929.53  929.79  929.89  929.94  929.96  929.97  929.97
 29    926.00  928.50  928.49  928.47  928.42  928.32  928.16  927.95  927.68  927.36  926.98  926.57  925.96  924.94  923.66
       924.56  925.47  926.16  927.05  928.49  929.26  929.59  929.74  929.82  929.88  929.91  929.92  929.93
 30    926.00  928.47  928.48  928.50  928.48  928.42  928.31  928.15  927.93  927.66  927.36  927.04  926.59  925.82  924.88
       923.61  925.16  926.22  927.37  928.66  929.15  929.35  929.47  929.57  929.69  929.76  929.80  929.82
 31    926.00  928.31  928.38  928.45  928.49  928.47  928.40  928.27  928.08  927.84  927.58  927.30  926.94  926.31  925.46
       923.65  924.30  925.63  927.34  927.99  928.24  928.36  928.53  928.74  929.18  929.37  929.46  929.50
 32    926.00  927.99  928.15  928.32  928.44  928.48  928.44  928.33  928.15  927.91  927.63  927.36  927.04  926.54  925.96
       925.06  923.63  923.54  923.51  923.51  923.51  923.52  924.65  925.38  927.79  928.27  928.48  928.60
 33    926.00  927.36  927.79  928.15  928.36  928.46  928.45  928.35  928.17  927.89  927.53  927.20  926.83  926.41  926.04
       925.70  925.32  925.83  927.32  927.69  927.66  927.13  923.54  923.54  923.51  923.51  924.63  925.34
 34    926.00  926.13  927.36  927.98  928.30  928.44  928.45  928.35  928.15  927.80  927.22  926.77  926.14  925.75  925.51
       925.41  925.35  925.92  927.37  927.74  927.77  927.57  927.02  926.88  926.73  926.30  923.54  926.49
 35    926.00  926.00  926.00  926.00  926.00  926.00  926.00  926.00  926.00  926.00  926.60  926.10  924.50  924.40  924.20
       924.10  924.00  924.00  924.00  924.00  924.00  924.00  924.00  924.00  923.50  923.50  923.50  923.50


                 VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP  1 IN STRESS PERIOD  1
                 ---------------------------------------------------------------------------

     CUMULATIVE VOLUMES      L**3                               RATES FOR THIS TIME STEP      L**3/T
     ------------------                                         ------------------------

           IN:                                                        IN:
           ---                                                        ---
                STORAGE =  0.73251E+07                                     STORAGE =  20055.
          CONSTANT HEAD =  0.56729E+07                               CONSTANT HEAD =  15532.
                 DRAINS =  0.00000                                          DRAINS =  0.00000
               RECHARGE =  0.13763E+07                                    RECHARGE =  3768.0
          RIVER LEAKAGE =  0.00000                                   RIVER LEAKAGE =  0.00000
```

TOTAL IN =	0.14374E+08	TOTAL IN =	39355.
OUT:		OUT:	
----		----	
STORAGE =	0.17571E+07	STORAGE =	4810.7
CONSTANT HEAD =	0.59716E+06	CONSTANT HEAD =	1634.9
DRAINS =	0.39344E+07	DRAINS =	10772.
RECHARGE =	0.00000	RECHARGE =	0.00000
RIVER LEAKAGE =	0.80981E+07	RIVER LEAKAGE =	22171.
TOTAL OUT =	0.14387E+08	TOTAL OUT =	39389.
IN - OUT =	-12423.	IN - OUT =	-34.008
PERCENT DISCREPANCY =	-0.09	PERCENT DISCREPANCY =	-0.09

TIME SUMMARY AT END OF TIME STEP 1 IN STRESS PERIOD 1

	SECONDS	MINUTES	HOURS	DAYS	YEARS
TIME STEP LENGTH	0.315576E+08	525960.	8766.00	365.250	1.00000
STRESS PERIOD TIME	0.315576E+08	525960.	8766.00	365.250	1.00000
TOTAL SIMULATION TIME	0.315576E+08	525960.	8766.00	365.250	1.00000

APPENDIX L

EQUATIONS FOR ESTIMATING LEVELS OF EXPOSURE

Table Index

Land Use	Receptor	Pathway	Exposure Equations: Inhalation	Ingestion	Dermal
Current	Trespasser	Ambient Air	L-1	-	-
"	"	Surface Soil	-	L-2	L-3
"	"	Creek Surface Water	-	L-4	L-5
"	"	Wetland Surface Water	-	L-6	L-7
"	"	Creek Sediment	-	L-8	L-9
"	"	Wetland Sediment	-	L-10	L-11
"	Off-Site Resident	Ambient Air	L-12	-	-
Future	Park User	Ambient Air	L-13	-	-
"	"	Surface Soil	-	L-14	L-15
"	"	Creek Surface Water	-	L-16	L-17
"	"	Wetland Surface Water	-	L-18	L-19
"	"	Creek Sediment	-	L-20	L-21
"	"	Wetland Sediment	-	L-22	L-23
"	"	Groundwater (Leachate)	-	L-46	-
"	On-Site Resident	Ambient Air	L-12	-	-
"	"	Surface Soil	-	L-24	L-25
"	"	Vegetables	-	L-26	-
"	"	Groundwater (Leachate)	L-27	L-28	L-29
"	"	Creek Surface Water	-	L-30	L-31
"	"	Wetland Surface Water	-	L-32	L-33
"	"	Creek Sediment	-	L-34	L-35
"	"	Wetland Sediment	-	L-36	L-37
"	"	Indoor Air	L-38	-	-
"	Off-Site Resident	Ambient Air	L-12	-	-
"	"	Groundwater (Aquifer)	L-39	L-40	L-41
"	"	Creek Surface Water	-	L-42	L-43
"	"	Creek Sediment	-	L-44	L-45

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Table L-1

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Inhalation of volatile chemicals while on-Site

$$\text{Intake (mg/kg-day)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

CA = Contaminant concentration in air (mg/m^3)

IR = Inhalation rate (m^3/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CA - Modeled concentration

IR - 1.2 m^3/hours, 50% heavy activity and 50% light activity while on-Site (U.S. EPA, 1989)

ET - 4 hours/day (U.S. EPA, 1991b)

EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)

ED - 10 years (professional judgement)

BW - 40 kg; 50th percentile time weighted average for older children 7 to 16 years old (U.S. EPA, 1989)

AT - 3,650 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-2

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Incidental ingestion of surface soils

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (kg/mg)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific
IR - 100 mg soil/day (U.S. EPA, 1989)
CF - 10^{-6} kg/mg
FI - Assume 90% (professional judgement based on approximate area of soil versus area of other media on-site)
EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)
ED - 10 years (professional judgement)
BW - 40 kg; 50th percentile time weighted average body weight for older children 7-16 years old (U.S. EPA, 1989)
AT - 3,650 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-3

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Dermal absorption of chemicals in surface soils

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)

CF = Conversion factor (kg/mg)

SA = Skin surface area available for contact (cm^2)

AF = Soil to skin adherence factor (mg/cm^2)

ABS = Absorption factor (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific

CF - 10^{-6} kg/mg

SA - 1,490 cm^2; hands and feet-50th percentile (U.S. EPA, 1989) time weighted average for children ages 7 to 16 years old.

AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)[1]

ABS - Assume 30% for organic compounds and 1% for inorganic compounds

EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)

ED - 10 years (professional judgement)

BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7-16 years old (U.S. EPA, 1989)

AT - 3,650 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

****

1. Based on the texture of the soils collected during the RI, it was determined that the soil to skin adherence factor for potting soil would most appropriately represent the adherence potential of surface soils at the Site. The alternate choice would have been to use the soil to skin adherence factor for pure kaolin clay, but because predominantly clay surface soils were not present on-Site, this factor was not considered appropriate to use.

Table L-4

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Incidental ingestion of surface water while playing in Kishwaukee Creek

$$\text{Intake (mg/kg-day)} = \frac{CW \times CR \times ET \times EF \times ED \times FI}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)

CR = Contact rate (L/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

FI = Fraction ingested from contaminated source (unitless)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

CR - 0.05L/hr (U.S. EPA, 1989)

ET - 1 hour/day (professional judgement)

EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)

ED - 10 years (professional judgement)

FI - Assume 5% (professional judgement based on approximate area of surface water versus area of other media on-site)

BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7 to 16 years old (U.S. EPA, 1989)

AT - 3,650 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-5

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older Child playing (trespassing) on-Site
- Dermal absorption of chemicals in surface water while playing in Kishwaukee Creek

$$\text{Absorbed dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)

SA = Skin surface area available for contact (cm^2)

PC = Chemical-specific dermal permeability constant (cm/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

CF = Volumetric conversion factor for water (L/cm^3)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

SA - 5,010 cm^2/event hands, legs and feet - 50th percentile (U.S. EPA, 1989) time weighted average for children ages 7 to 16 years old.

PC - Chemical-specific (Table 7-17)

ET - 1 hour/day (professional judgement)

EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)

ED - 10 years (professional judgement)

CF - 1L/1000 cm^3

BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7-16 years old (U.S. EPA, 1989)

AT - 3,650 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-6

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Child playing (trespassing) on-Site
- Incidental ingestion of surface water while playing in wetlands

$$\text{Intake (mg/kg-day)} = \frac{CW \times CR \times ET \times EF \times ED \times FI}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)
CR = Contact rate (L/hour)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
FI = Fraction ingested from contaminated source (unitless)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific
CR - 0.05L/hr (U.S. EPA, 1989)
ET - 1 hour/day (professional judgement)
EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)
ED - 10 years (professional judgement)
FI - Assume 5% (professional judgement based on approximate area of surface water versus the area of other media on-site)
BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7 to 16 years old (U.S. EPA, 1989)
AT - 3,650 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-7

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Dermal absorption of chemicals in surface water while playing in wetlands

$$\text{Absorbed dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)

SA = Skin surface area available for contact (cm^2)

PC = Chemical-specific dermal permeability constant (cm/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

CF = Volumetric conversion factor for water (L/cm^3)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

SA - 1,490 cm^2/event; hands and feet-50th percentile (U.S. EPA, 1989) time weighted average for children ages 7 to 16 years old.

PC - Chemical-specific (Table 7-17)

ET - 1 hour/day (professional judgement)

EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)

ED - 10 years (professional judgement)

CF - 1L/1000 cm^3

BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7-16 years old (U.S. EPA, 1989)

AT - 3,650 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-8

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Incidental ingestion of Kishwaukee Creek sediments

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (kg/mg)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific
IR - 100 mg sediment/day (U.S. EPA, 1989)
CF - 10^{-6} kg/mg
FI - Assume 5% (professional judgement based on approximate area of sediment versus area of other media on-site)
EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)
ED - 10 years (professional judgement)
BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7 to 16 years old (U.S. EPA, 1989)
AT - 3,650 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-9

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Dermal absorption of chemicals in Kishwaukee Creek

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)

CF = Conversion factor (kg/mg)

SA = Skin surface area available for contact (cm^2)

AF = Sediment to skin adherence factor (mg/cm^2)

ABS = Absorption factor (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific

CF - 10^{-6} kg/mg

SA - 1,490 cm^2 (Kishwaukee Creek); hands and feet 50th percentile (U.S. EPA, 1989) time weighted average for children ages 7 to 16 years old.

AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)[2]

ABS - Assume 30% for organic compounds and 1% for inorganic compounds

EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)

ED - 10 years (professional judgement)

BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7 to 16 years old (U.S. EPA, 1989)

AT - 3,650 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

****

2. In the available literature, there was no sediment to skin adherence factors, therefore, soil to skin adherence factors had to be used to represent the adherence potential of sediments. Based on the texture of the sediments collected during the RI and their observed organic matter content, it was determined that the soil to skin adherence factor for potting soil would most appropriately represent the adherence potential of sediments at the Site. The alternate choice would have been to use the soil to skin adherence factor for pure kaolin clay, but because predominantly organic free clay sediments were not present on-Site, this factor was not considered appropriate to use.

Table L-10

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Incidental ingestion of wetland sediments

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (kg/mg)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific
IR - 100 mg sediment/day (U.S. EPA, 1989)
CF - 10^{-6} kg/mg
FI - Assume 5% (professional judgement based on approximate area of sediments versus area of other media on-site)
EF - 4 days/wk x 35 wk/year = 140 days/year (professional judgement)
ED - 10 years (professional judgement)
BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7 to 16 years old (U.S. EPA, 1989)
AT - 3,650 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-11

CURRENT USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Older child playing (trespassing) on-Site
- Dermal absorption of chemicals in wetland sediments

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)

CF = Conversion factor (kg/mg)

SA = Skin surface area available for contact (cm^2)

AF = Sediment to skin adherence factor (mg/cm^2)

ABS = Absorption factor (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific

CF - 10^{-6} kg/mg

SA - 1,490 cm^2; hands and feet-50th percentile (U.S. EPA, 1989) time weighted average for children ages 7 to 16 years old.

AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)[3]

ABS - Assume 30% for organic compounds and 1% for inorganic compounds

EF - 4 days/wk x 35 wk/year = 140 days/year (U.S. EPA, 1991b)

ED - 10 years (professional judgement)

BW - 40 kg; 50th percentile time weighted average body weight for older children ages 7 to 16 years old (U.S. EPA, 1989)

AT - 3,650 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

****

3. In the available literature, there was no sediment to skin adherence factors, therefore, soil to skin adherence factors had to be used to represent the adherence potential of sediments. Based on the texture of the sediments collected during the RI and their observed organic matter content, it was determined that the soil to skin adherence factor for potting soil would most appropriately represent the adherence potential of sediments at the Site. The alternate choice would have been to use the soil to skin adherence factor for pure kaolin clay, but because predominantly organic free clay sediments were not present on-Site, this factor was not considered appropriate to use.

Table L-12

CURRENT AND FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Off-Site (current and future) or on-Site resident (future)
- Inhalation of volatile chemicals released to air due to landfill gas generation

$$\text{Intake (mg/kg-day)} = \frac{CA \times IR \times EF \times ED}{BW \times AT}$$

CA = Contaminant concentration in air (mg/m^3)
IR = Inhalation rate (m^3/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CA - Modeled concentration
IR - 20 m^3/day (U.S. EPA, 1989)
EF - 350 days/year (U.S. EPA, 1991a)
ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg + 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-13

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Inhalation of volatile chemicals released to air due to landfill gas generation

$$\text{Intake (mg/kg-day)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

CA = Contaminant concentration in air (mg/m^3)
IR = Inhalation rate (m^3/hour)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CA - Modeled concentration
IR - 1.2 m^3/hours, 50% heavy activity and 50% light activity while on-Site (U.S. EPA, 1989)
ET - 4 hours/day (professional judgement)
EF - 4 days/wk x 35 weeks/year = 140 days/year (professional judgement)
ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg + 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-14

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Incidental ingestion of surface soils

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)

IR = Ingestion rate (mg/soil/day)

CF = Conversion factor (10^{-6} kg/mg)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific

IR - 120 mg soil/day (U.S. EPA, 1991a)

CF - 10^{-6} kg/mg

FI - Assume 90% (professional judgement based on approximate area of surface soil versus area of other media on-site)

EF - 4 days/week x 35 weeks/year = 140 days/year (U.S. EPA, 1991b)

ED - 30 years (U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-15

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Dermal absorption of chemicals in surface soils

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)
CF = Conversion factor (kg/mg)
SA = Skin surface area available for contact (cm^2/event)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific
CF - 10^{-6} kg/mg
SA - 2,170 cm^2 hands and feet-Time weighted estimate for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)
AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)
ABS - Assume 30% for organic chemicals and 1% for inorganic chemicals
EF - 4 days/week x 35 weeks/year = 140 days/week (U.S. EPA, 1991b)
ED - 30 years (U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-16

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Ingestion of Kishwaukee Creek surface water

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times FI \times EF \times ED}{BW \times AT}$$

CW = Chemical concentration in water (mg/kg)

IR = Ingestion rate (L/day)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

IR - 0.05 L/day (U.S. EPA, 1989)

FI - Assume 5% (professional judgement based on approximate area of surface water versus other media on-site)

EF - 4 days/week x 35 weeks/year = 140 days/year (U.S. EPA, 1991b)

ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-17

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Dermal absorption of chemicals in Kishwaukee Creek surface water

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)
SA = Skin surface area available for contact (cm^2)
PC = Chemical-specific dermal permeability constant (cm/hour)
ET = Exposure time (hours/day)
EF = Exposure frequency (day/year)
ED = Exposure duration (years)
CF = Volumetric conversion factor for water (L/cm^3)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific
SA - 7,940 cm^2 hands, legs and feet - time weighted estimate (50th percentile) for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)
PC - Chemical-specific (Table 7-17)
ET - 1.0 hrs/day (professional judgement)
EF - 4 days/week x 35 weeks/year = 140 days/year (U.S. EPA, 1991b)
ED - 30 years (U.S. EPA, 1989)
CF - $1L/1000\ cm^3$
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects), 25,550 (carcinogenic effects)

Table L-18

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Ingestion of wetlands surface water

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times FI \times EF \times ED}{BW \times AT}$$

CW = Chemical concentration in water (mg/kg)
IR = Ingestion rate (L/day)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific
IR - 0.05 L/day (U.S. EPA, 1989)
FI - Assume 5% (professional judgement based on approximate area of surface water versus area of other media on-site)
EF - 4 days/week x 35 weeks/year = 140 days/year (U.S. EPA, 1991b)
ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)
BW - 69 kg = of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991)
AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-19

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Dermal absorption of chemicals in wetlands surface water

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)
SA = Skin surface area available for contact (cm^2)
PC = Chemical-specific dermal permeability constant (cm/hour)
ET = Exposure time (hours/day)
EF = Exposure frequency (day/year)
ED = Exposure duration (years)
CF = Volumetric conversion factor for water (L/cm^3)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific
SA - 7,940 cm^2 hands, legs and feet - Time weighted estimate for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)
PC - Chemical-specific (Table 7-17)
ET - 1.0 hr/day (professional judgement)
EF - 4 days/week x 35 weeks/year = 140 days/year (U.S. EPA, 1991b)
ED - 30 years (U.S. EPA, 1989)
CF - 1L/1000 cm^3
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects), 25,550 (carcinogenic effects)

Table L-20

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Incidental ingestion of Kishwaukee Creek sediments

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)

IR = Ingestion rate (mg/soil/day)

CF = Conversion factor (10^{-6} kg/mg)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific

IR - 120 mg sediment/day (U.S. EPA, 1989)

CF - 10^{-6} kg/mg

FI - Assume 5% (professional judgement based on approximate area of sediments versus area of other media on-site)

EF - 4 days/week x 35 weeks/year = 140 days/year (U.S. EPA, 1991b)

ED - 30 years (U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-21

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Dermal absorption of chemicals in Kishwaukee Creek sediment

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)
CF = Conversion factor (kg/mg)
SA = Skin surface area available for contact (cm^2/event)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific
CF - 10^{-6} kg/mg
SA - 2,170 cm^2 hands and feet - time weighted estimate (50th percentile) for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)
AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)
ABS - Assume 30% for organic chemicals and 1% for inorganic chemicals
EF - 4 days/week x 35 weeks/year = 140 days/week (U.S. EPA 1991b)
ED - 30 years (U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-22

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Incidental ingestion of wetlands sediment

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)
IR = Ingestion rate (mg/soil/day)
CF = Conversion factor (10^{-6} kg/mg)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific
IR - 120 mg sediment/day (U.S. EPA, 1991a)
CF - 10^{-6} kg/mg
FI - Assume 5% (professional judgement based on approximate area of sediments versus area of other media on-site)
EF - 4 days/week x 35 weeks/year = 140 days/year (U.S. EPA, 1991b)
ED - 30 years (U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-23

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Dermal absorption of chemicals in wetlands sediment

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)

CF = Conversion factor (kg/mg)

SA = Skin surface area available for contact (cm^2/event)

AF = Soil to skin adherence factor (mg/cm^2)

ABS = Absorption factor (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific

CF - 10^{-6} kg/mg

SA - 2,170 cm^2 hands and feet - time weighted estimate (50th percentile) for persons (male and female) from birth to age 30 years old (U.S. EPA, 1989)

AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)

ABS - Assume 30% for organic chemicals and 1% for inorganic chemicals

EF - 4 days/week x 35 weeks/year = 140 days/week (U.S. EPA, 1991b)

ED - 30 years (U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-24

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Incidental ingestion of surface soils

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)

IR = Ingestion rate (mg/soil/day)

CF = Conversion factor (10^{-6} kg/mg)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific

IR - 120 mg soil/day (U.S. EPA, 1991)

CF - 10^{-6} kg/mg

FI - Assume 90% (professional judgement based on approximate area of surface soil versus area of other media on-site)

EF - 7 days/week x 50 weeks/year = 350 days/year (professional judgement)

ED - 30 years (U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-25

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Dermal absorption of chemicals in surface soils

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)

CF = Conversion factor (kg/mg)

SA = Skin surface area available for contact (cm^2/event)

AF = Soil to skin adherence factor (mg/cm^2)

ABS = Absorption factor (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific

CF - 10^{-6} kg/mg

SA - 2,170 cm^2 hands and feet - time weighted estimate (50% percentile) for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)

AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)

ABS - Assume 30% for organic chemicals and 1% for inorganic chemicals

EF - 7 days/week x 50 weeks/year = 350 days/week (U.S. EPA, 1991a)

ED - 30 years (U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-26

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site Resident
- Consumption of homegrown vegetables

$$\text{Intake (mg/kg-day)} = \frac{CS \times TF \times IR \times FI \times EF \times ED}{BW \times AT}$$

CS = Soil contaminant concentration(mg/kg)

TF = Soil to plant translocation factor (unitless)

IR = Ingestion rate for produce category (kg/day)

FI = Fraction ingested from contaminated garden (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged - days)

CS - Chemical specific soil concentrations (see Table 8-14)

TF = Chemical specific soil to plant uptake factors (see Table 8-14)

IR = Vegetable specific ingestion rates (see Table 8-14)

FI = 0.4 (U.S. EPA, 1989)

EF = 365 (vegetable ingestion rates are daily averages for the year)

ED = 30 years (U.S. EPA, 1989)

BW = 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT = 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-27

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-site resident
- Inhalation of volatiles released from groundwater while showering using leachate as source

$$\text{Intake (mg/kg-day)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

CA = Contaminant concentration in air (mg/m^3)

IR = Inhalation rate (m^3/day)

ET = Exposure time (hours/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CA - Modeled - see Appendix R

IR - See Appendix R

ET - See Appendix R

EF - 350 days/year (U.S. EPA, 1991a)

ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 3,650 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-28

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-site resident
- Ingestion of groundwater using leachate as source

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

CW = Contaminant concentration in water (mg/L)

IR = Ingestion rate (L/day)

EF = Exposure frequency (day/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

IR - 2 L/day (U.S. EPA, 1989)

EF - 350 days/year (U.S. EPA, 1991a)

ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-29

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Dermal absorption of chemicals in water while bathing using leachate as source

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)
SA = Skin surface area available for contact (cm^2)
PC = Chemical-specific dermal permeability constant (cm/hour)
ET = Exposure time (hours/day)
EF = Exposure frequency (day/year)
ED = Exposure duration (years)
CF = Volumetric conversion factor for water (L/cm^3)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific
SA - 18,150 cm^2; time weighted estimate (50% percentile) for persons (male and female) from birth to 30 years old - total body surface area (U.S. EPA, 1989)
PC - Chemical-specific (Table 8-18)
ET - 0.2 hrs/day (U.S. EPA, 1989)
EF - 350 days/year (U.S. EPA, 1991a)
ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)
CF - 1L/1000 cm^3
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects), 25,550 (carcinogenic effects)

Table L-30

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Ingestion of Kishwaukee Creek surface water

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times FI \times EF \times ED}{BW \times AT}$$

CW = Chemical concentration in water (mg/kg)
IR = Ingestion rate (L/day)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific
IR - 0.05 L/day (U.S. EPA, 1989)
FI - Assume 5% (professional judgement based on approximate area of surface water versus area of other media on-site)
EF - 7 days/week x 35 weeks/year = 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when weather is conducive to outdoor gardening activities)
ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-31

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Dermal absorption of chemicals in Kishwaukee Creek surface water

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)

SA = Skin surface area available for contact (cm^2)

PC = Chemical-specific dermal permeability constant (cm/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (day/year)

ED = Exposure duration (years)

CF = Volumetric conversion factor for water (L/cm^3)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

SA - 7,940 cm^2 hands, legs and feet - time weighted estimate (50th percentile) for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)

PC - Chemical-specific (Table 8-18)

ET - 1.0 hrs/day (U.S. EPA, 1989)

EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor activities)

ED - 30 years (U.S. EPA, 1989)

CF - $1L/1000\ cm^3$

BW - 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg = 59 kg (Supplemental Guidance)

AT - 10,950 days (noncarcinogenic effects), 25,550 (carcinogenic effects)

Table L-32

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Ingestion of wetlands surface water

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times FI \times EF \times ED}{BW \times AT}$$

CW = Chemical concentration in water (mg/kg)

IR = Ingestion rate (L/day)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

IR - 0.05 L/day (U.S. EPA, 1989)

FI - Assume 5% (professional judgement based on approximate area of surface water versus the area of other media on-site)

EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when weather is conducive to outdoor activities)

ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)

BW - 59 ug/kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-33

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Dermal absorption of chemicals in wetlands surface water

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)

SA = Skin surface area available for contact (cm^2)

PC = Chemical-specific dermal permeability constant (cm/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (day/year)

ED = Exposure duration (years)

CF = Volumetric conversion factor for water (L/cm^3)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

SA - 7,940 cm^2 hands, legs and feet - time weighted estimate (50th percentile) for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)

PC - Chemical-specific (Table 8-18)

ET - 1.0 hr/day (professional judgement)

EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor gardening activities)

ED - 30 years (U.S. EPA, 1989)

CF - $1L/1000\ cm^3$

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 (carcinogenic effects)

Table L-34

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Incidental ingestion of Kishwaukee Creek sediment

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)

IR = Ingestion rate (mg/soil/day)

CF = Conversion factor (10^{-6} kg/mg)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific

IR - 120 mg soil/day (U.S. EPA, 1991a)

CF - 10^{-6} kg/mg

FI - Assume 5% (professional judgement based on approximate area of sediment versus the area of other media on-site)

EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor)

ED - 30 years (U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-35

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Dermal absorption of chemicals in Kishwaukee Creek sediment

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)
CF = Conversion factor (kg/mg)
SA = Skin surface area available for contact (cm^2/event)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific
CF - 10^{-6} kg/mg
SA - 2,170 cm^2 hands and feet - time weighted estimate (50th percentile) for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)
AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)
ABS - Assume 30% for organic chemicals and 1% for inorganic chemicals
EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor activities)
ED - 30 years (U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-36

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- *Hypothetical on-Site resident*
- Incidental ingestion of wetlands sediment

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)

IR = Ingestion rate (mg/soil/day)

CF = Conversion factor (10^{-6} kg/mg)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific

IR - 120 mg soil/day (U.S. EPA, 1989)

CF - 10^{-6} kg/mg

FI - Assume 5% (professional judgement based on approximate area of sediments versus the area of other media on-site)

EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor activities)

ED - 30 years (U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-37

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Dermal absorption of chemicals in wetlands sediment

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)
CF = Conversion factor (kg/mg)
SA = Skin surface area available for contact (cm^2/event)
AF = Sediment to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific
CF - 10^{-6} kg/mg
SA - 2,170 cm^2 hands and feet-50th percentile for adults (U.S. EPA, 1989)
AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)
ABS - Assume 30% for organic chemicals and 1% for inorganic chemicals
EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor activities)
ED - 30 years (U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

Table L-38

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical on-Site resident
- Inhalation of volatile chemicals released indoors due to landfill gas migration

$$\text{Intake (mg/kg-day)} = \frac{CA \times IR \times EF \times ED}{BW \times AT}$$

CA = Contaminant concentration in air (mg/m^3)

IR = Inhalation rate (m^3/day)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CA - Modeled concentration

IR - 20 m^3/day (U.S. EPA, 1989)

EF - 350 days/year (U.S. EPA, 1991a)

ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-39

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical off-Site resident
- Inhalation of volatiles released from groundwater while showering

$$\text{Intake (mg/kg-day)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

CA = Contaminant concentration in air (mg/m^3)
IR = Inhalation rate (m^3/day)
ET = Exposure time (hours/day)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CA - Modeled - see Appendix R
IR - See Appendix R
ET - See Appendix R
EF - 350 days/year (U.S. EPA, 1991a)
ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-40

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical off-Site resident
- Ingestion of groundwater

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

CW = Contaminant concentration in water (mg/L)

IR = Ingestion rate (L/day)

EF = Exposure frequency (day/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

IR - 2 L/day (U.S. EPA, 1989)

EF - 350 days/year (U.S. EPA 1991a)

ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-41

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical off-Site resident
- Dermal absorption of chemicals in water while bathing

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)

SA = Skin surface area available for contact (cm^2)

PC = Chemical-specific dermal permeability constant (cm/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (day/year)

ED = Exposure duration (years)

CF = Volumetric conversion factor for water (L/cm^3)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

SA - 18,150 cm^2; time weighted estimate (50th percentile) for persons (male and female) from birth to 30 years old - total body surface area (U.S. EPA, 1989)

PC - Chemical-specific (Table 8-18)

ET - 0.2 hrs/day (U.S. EPA, 1989)

EF - 350 days/year (U.S. EPA, 1991a)

ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)

CF - 1L/1000 cm^3

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 (carcinogenic effects)

Table L-42

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical off-Site resident
- Ingestion of Kishwaukee Creek surface water

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times FI \times EF \times ED}{BW \times AT}$$

CW = Chemical concentration in water (mg/kg)

IR = Ingestion rate (L/day)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

IR - 0.05 L/day (U.S. EPA, 1989)

FI - Assume 10% (professional judgement based on assumed area of surface water versus the area of other off-site medium)

EF - 240 days/ year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor activities).

ED - 30 years (national upper-bound time at one residence; U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-43

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical off-Site resident
- Dermal absorption of chemicals in Kishwaukee Creek surface water

$$\text{Absorbed Dose (mg/kg-day)} = \frac{CW \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT}$$

CW = Chemical concentration in water (mg/L)

SA = Skin surface area available for contact (cm^2)

PC = Chemical-specific dermal permeability constant (cm/hour)

ET = Exposure time (hours/day)

EF = Exposure frequency (day/year)

ED = Exposure duration (years)

CF = Volumetric conversion factor for water (L/cm^3)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific

SA - 7,940 cm^2 hands, legs and feet - time weighted estimate (50th percentile)for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)

PC - Chemical-specific (Table 8-18)

ET - 1.0 hrs/day (professional judgement)

EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor activities)

ED - 30 years (U.S. EPA, 1989)

CF - 1L/1000 cm^3

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 (carcinogenic effects)

Table L-44

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical off-Site resident
- Incidental ingestion of Kishwaukee Creek sediment

$$\text{Intake (mg/kg-day)} = \frac{CS \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in sediment (mg/kg)

IR = Ingestion rate (mg/soil/day)

CF = Conversion factor (10^{-6} kg/mg)

FI = Fraction ingested from contaminated source (unitless)

EF = Exposure frequency (days/year)

ED = Exposure duration (years)

BW = Body weight (kg)

AT = Averaging time (period over which exposure is averaged--days)

CS - Site-specific

IR - 120 mg sediment/day (U.S. EPA, 1991a)

CF - 10^{-6} kg/mg

FI - Assume 10% (professional judgement based on assumed area of sediment versus the area of other off-site medium)

EF - 240 days/year (professional judgement - assume exposure occurs daily for eight months per year during spring, summer, and fall when the weather is conducive to outdoor activities)

ED - 30 years (U.S. EPA, 1989)

BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg U.S. EPA, 1991a)

AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

Table L-45

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical off-Site resident
- Dermal absorption of chemicals in Kishwaukee Creek sediment

$$\text{Absorbed dose (mg/kg-day)} = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

CS = Chemical concentration in soil (mg/kg)
CF = Conversion factor (kg/mg)
SA = Skin surface area available for contact (cm^2/event)
AF = Soil to skin adherence factor (mg/cm^2)
ABS = Absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CS - Site specific
CF - 10^{-6} kg/mg
SA - 2,170 cm^2 hands and feet - time weighted estimate (50th percentile) for persons (male and female) from birth to 30 years old (U.S. EPA, 1989)
AF - 1.45 mg/cm^2; potting soil (U.S. EPA, 1989)
ABS - Assume 30% for organic chemicals and 1% for inorganic chemicals
EF - 240 days/week (professional judgement - assume exposure occurs daily for eight month sper year during spring, summer, and fall when the weather is conducive to outdoor activities)
ED - 30 years (U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects) 25,550 days (carcinogenic effects)

[mad-602-22g]

Table L-46

FUTURE USE EXPOSURE

Woodstock Municipal Landfill
Remedial Investigation
Woodstock, Illinois

- Hypothetical park user
- Ingestion of groundwater using leachate as source

$$\text{Intake (mg/kg-day)} = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

CW = Contaminant concentration in water (mg/L)
IR = Ingestion rate (L/day)
EF = Exposure frequency (day/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged--days)

CW - Site-specific
IR - 0.5 L/day (Refer to Section 8.3.6.1 for explanation)
EF - 4 days/week x 35 weeks/year = 140 days/year (U.S. EPA, 1991b)
ED - 30 years (U.S. EPA, 1989)
BW - 59 kg = 6 of 30 years at 15 kg plus 24 of 30 years at 70 kg (U.S. EPA, 1991a)
AT - 10,950 days (noncarcinogenic effects), 25,550 days (carcinogenic effects)

[mad-602-22g]

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APPENDIX M

EXPOSURE ESTIMATES

Appendix M
Exposure Estimates Table Index

Land Use	Receptor	Pathway	Exposure Estimates
Current	Trespasser	Ambient Air	M-1
"	"	Surface Soil	M-2
"	"	Creek Surface Water	M-3
"	"	Wetland Surface Water	M-4
"	"	Creek Sediment	M-5
"	"	Wetland Sediment	M-6
"	Off-Site Resident	Ambient Air	M-7
ture	Park User	Ambient Air	M-8
"	"	Surface Soil	M-9
"	"	Creek Surface Water	M-10
"	"	Wetland Surface Water	M-11
"	"	Creek Sediment	M-12
"	"	Wetland Sediment	M-13
"	On-Site Resident	Ambient Air	M-14
"	"	Surface Soil	M-15
"	"	Vegetables	M-16
"	"	Groundwater (Leachate)	M-17
"	"	Creek Surface Water	M-18
"	"	Wetland Surface Water	M-19
"	"	Creek Sediment	M-20
"	"	Wetland Sediment	M-21
"	"	Indoor Air	M-22
"	Off-Site Resident	Ambient Air	M-23
"	"	Groundwater (Aquifer)	M-24
"	"	Creek Surface Water	M-25
"	"	Creek Sediment	M-26

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H/jah/MWK

Table M-1

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: Trespassers
Land Use: Current Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)	CARCINOGENS (mg/kg-d)
	Inhalation	Inhalation
VOLATILES		
Chloroethane	2.0e-06	2.9e-07
Benzene	1.2e-06	1.7e-07
Toluene	8.1e-07	1.2e-07
Chlorobenzene	9.2e-07	1.3e-07
Ethylbenzene	2.2e-06	3.2e-07
Xylenes (mixed)	3.1e-06	4.5e-07
Freon	9.0e-07	1.3e-07
4-Ethyl Toluene	1.3e-06	1.8e-07
1,3,5-Trimethylbenzene	5.7e-07	8.1e-08
1,2,4-Trimethylbenzene	2.6e-06	3.7e-07

(a) Values not available for Freon-114, dichlorodifluoroethane used.
(b) Values for ethyl toluene not available, toluene used instead.
(c) Values for trimethylbenzene not available, toluene used instead.

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chronic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

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JAH/jah/TB/MWK

Table M-2

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Soil
Source Area: Landfill

Population: Trespasser
Land Use: Current use scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
4-Chloroaniline	1.2e-06	1.7e-07	0.0e+00	1.8e-07	2.5e-08	0.0e+00
Dimethylphthalate	6.2e-07	8.6e-08	0.0e+00	8.9e-08	1.2e-08	0.0e+00
Phenanthrene	4.9e-07	6.8e-08	0.0e+00	7.0e-08	9.7e-09	0.0e+00
Di-n-butylphthalate	1.5e-06	2.1e-07	0.0e+00	2.1e-07	3.0e-08	0.0e+00
Fluoranthene	1.4e-06	1.9e-07	0.0e+00	2.0e-07	2.7e-08	0.0e+00
Pyrene	1.6e-06	2.2e-07	0.0e+00	2.3e-07	3.2e-08	0.0e+00
Butylbenzylphthalate	1.8e-06	2.5e-07	0.0e+00	2.6e-07	3.6e-08	0.0e+00
Benzo(a)anthracene	9.9e-07	1.4e-07	0.0e+00	1.4e-07	2.0e-08	0.0e+00
Chrysene	1.1e-06	1.6e-07	0.0e+00	1.6e-07	2.2e-08	0.0e+00
Benzo(b)fluoranthene	4.3e-06	6.0e-07	0.0e+00	6.1e-07	8.5e-08	0.0e+00
Benzo(k)fluoranthene	4.3e-06	6.0e-07	0.0e+00	6.1e-07	8.5e-08	0.0e+00
Benzo(a)pyrene	1.1e-06	1.5e-07	0.0e+00	1.5e-07	2.1e-08	0.0e+00
Ideno(1,2,3-cd)pyrene	6.2e-07	8.6e-08	0.0e+00	8.9e-08	1.2e-08	0.0e+00
Dibenz(a,h)anthracene	3.0e-07	4.1e-08	0.0e+00	4.3e-08	5.9e-09	0.0e+00
Benzo(g,h,i)perylene	6.8e-07	9.5e-08	0.0e+00	9.8e-08	1.4e-08	0.0e+00
Total Carcinogenic PAHs	1.3e-05	1.8e-06	0.0e+00	1.8e-06	2.5e-07	0.0e+00
METALS						
Barium	8.5e-05	3.6e-04	0.0e+00	1.2e-05	5.1e-05	0.0e+00
Cadmium (food/soil)	4.8e-07	2.0e-06	0.0e+00	6.8e-08	2.8e-07	0.0e+00
Chromium VI	1.6e-05	6.5e-05	0.0e+00	2.2e-06	9.3e-06	0.0e+00
Copper	1.2e-04	5.1e-04	0.0e+00	1.7e-05	7.3e-05	0.0e+00
Mercury	4.6e-07	1.9e-06	0.0e+00	6.5e-08	2.7e-07	0.0e+00
Nickel	1.1e-05	4.4e-05	0.0e+00	1.5e-06	6.3e-06	0.0e+00
Silver	2.1e-06	8.9e-06	0.0e+00	3.0e-07	1.3e-06	0.0e+00
Zinc	1.4e-04	5.9e-04	0.0e+00	2.0e-05	8.5e-05	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

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3/12/92
JAH/jah/TB/MWK

Table M-3

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Kishwaukee Creek

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Zinc	1.3e-05	4.3e-06	0.0e+00	1.9e-06	6.2e-07	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for *carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between* the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

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3/12/92
JAH/jah/TB/MWK

Table M-4

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Wetlands

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Arsenic	5.1e-08	5.8e-08	0.0e+00	7.3e-09	8.2e-09	0.0e+00
Barium	4.8e-06	5.3e-06	0.0e+00	6.8e-07	7.6e-07	0.0e+00
Copper	3.0e-07	3.4e-07	0.0e+00	4.3e-08	4.8e-08	0.0e+00
Lead (3)	1.1e-07	1.3e-07	0.0e+00	1.6e-08	1.8e-08	0.0e+00
Manganese	1.4e-05	1.5e-05	0.0e+00	2.0e-06	2.2e-06	0.0e+00
Nickel	3.0e-06	3.4e-06	0.0e+00	4.3e-07	4.8e-07	0.0e+00
Zinc	5.7e-06	6.3e-06	0.0e+00	8.1e-07	9.0e-07	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

3. The U.S.EPA's lead uptake/biokinetic model was used to estimate lead intakes. Refer to section 8.5.1.2 of the baseline risk assessment for a discussion of this model.

[woodstock.2020.RA]CD-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-5

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Kishwaukee Creek

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Chromium VI	3.8e-06	8.7e-07	0.0e+00	5.4e-07	1.2e-07	0.0e+00
Cobalt	2.1e-07	3.3e-07	0.0e+00	3.1e-08	4.7e-08	0.0e+00
Copper	9.9e-07	1.5e-06	0.0e+00	1.4e-07	2.2e-07	0.0e+00
Nickel	5.9e-06	1.4e-06	0.0e+00	8.4e-07	2.0e-07	0.0e+00
Zinc	1.1e-04	2.5e-05	0.0e+00	1.5e-05	3.5e-06	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]CE-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-6

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Wetlands

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
VOLATILES						
2-Butanone	9.3e-08	7.2e-10	0.0e+00	1.3e-08	1.0e-10	0.0e+00
Toluene	5.7e-07	4.4e-09	0.0e+00	8.2e-08	6.3e-10	0.0e+00
SEMIVOLATILES						
Phenol	6.8e-06	5.3e-08	0.0e+00	9.8e-07	7.5e-09	0.0e+00
1,2-Dichlorobenzene	6.2e-07	4.8e-09	0.0e+00	8.9e-08	6.8e-10	0.0e+00
4-Methylphenol	1.1e-06	8.6e-09	0.0e+00	1.6e-07	1.2e-09	0.0e+00
Benzoic Acid	1.2e-06	9.1e-09	0.0e+00	1.7e-07	1.3e-09	0.0e+00
Fluoranthene	7.5e-07	5.8e-09	0.0e+00	1.1e-07	8.2e-10	0.0e+00
bis(2-ethylhexyl)phthalate	7.5e-06	5.8e-08	0.0e+00	1.1e-06	8.2e-09	0.0e+00
METALS						
Chromium VI	8.6e-06	2.0e-06	0.0e+00	1.2e-06	2.8e-07	0.0e+00
Copper	3.0e-05	6.9e-06	0.0e+00	4.3e-06	9.9e-07	0.0e+00
Mercury	6.2e-08	1.4e-08	0.0e+00	8.9e-09	2.1e-09	0.0e+00
Nickel	5.7e-05	1.3e-05	0.0e+00	8.1e-06	1.9e-06	0.0e+00
Selenium	6.0e-07	1.4e-07	0.0e+00	8.6e-08	2.0e-08	0.0e+00
Thallium	7.7e-07	1.8e-07	0.0e+00	1.1e-07	2.5e-08	0.0e+00
Zinc	1.7e-04	3.9e-05	0.0e+00	2.4e-05	5.5e-06	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]CF-I.w20
3/10/92
JAH/jah/TB/MWK

Table M-7

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: Off-Site Resident
Land Use: Current Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)	CARCINOGENS (mg/kg-d)
	Inhalation	Inhalation
VOLATILES		
Chloroethane	1.4e-05	6.1e-06
Benzene	8.2e-06	3.5e-06
Toluene	5.7e-06	2.4e-06
Chlorobenzene	6.5e-06	2.8e-06
Ethylbenzene	1.6e-05	6.7e-06
Xylenes (mixed)	2.2e-05	9.5e-06
Freon	6.3e-06	2.7e-06
4-Ethyl Toluene	9.1e-06	3.9e-06
1,3,5-Trimethylbenzene	4.0e-06	1.7e-06
1,2,4-Trimethylbenzene	1.8e-05	7.8e-06

(a) Values not available for Freon-114, dichlorodifluoroethane used.
(b) Values for ethyl toluene not available, toluene used instead.
(c) Values for trimethylbenzene not available, toluene used instead.

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]CG-I.w20
10/31/91
JAH/jah/TB/MWK

Table M-8

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: Park User
Land Use: Future Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)	CARCINOGENS (mg/kg-d)
	Inhalation	Inhalation
VOLATILES		
Chloroethane	1.4e-06	5.9e-07
Benzene	7.8e-07	3.4e-07
Toluene	5.5e-07	2.3e-07
Chlorobenzene	6.2e-07	2.7e-07
Ethylbenzene	1.5e-06	6.4e-07
Xylenes (mixed)	2.1e-06	9.1e-07
Freon	6.1e-07	2.6e-07
4-Ethyl Toluene	8.8e-07	3.8e-07
1,3,5-Trimethylbenzene	3.8e-07	1.6e-07
1,2,4-Trimethylbenzene	1.8e-06	7.5e-07

(a) Values not available for Freon-114, dichlorodifluoroethane used.
(b) Values for ethyl toluene not available, toluene used instead.
(c) Values for trimethylbenzene not available, toluene used instead.

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FA-I.w20
10/31/91
JAH/jah/TB/MWK

Table M-9

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Soil
Source Area: Landfill

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
SEMIVOLATILES						
4-Chloroaniline	1.2e-06	1.4e-07	0.0e+00	5.3e-07	6.0e-08	0.0e+00
Dimethylphthalate	6.1e-07	7.0e-08	0.0e+00	2.6e-07	3.0e-08	0.0e+00
Phenanthrene	4.8e-07	5.5e-08	0.0e+00	2.1e-07	2.4e-08	0.0e+00
Di-n-butylphthalate	1.5e-06	1.7e-07	0.0e+00	6.3e-07	7.2e-08	0.0e+00
Fluoranthene	1.4e-06	1.5e-07	0.0e+00	5.8e-07	6.6e-08	0.0e+00
Pyrene	1.6e-06	1.8e-07	0.0e+00	6.8e-07	7.8e-08	0.0e+00
Butylbenzylphthalate	1.8e-06	2.0e-07	0.0e+00	7.6e-07	8.7e-08	0.0e+00
Benzo(a)anthracene	9.8e-07	1.1e-07	0.0e+00	4.2e-07	4.8e-08	0.0e+00
Chrysene	1.1e-06	1.3e-07	0.0e+00	4.7e-07	5.4e-08	0.0e+00
Benzo(b)fluoranthene	4.2e-06	4.8e-07	0.0e+00	1.8e-06	2.1e-07	0.0e+00
Benzo(k)fluoranthene	4.2e-06	4.8e-07	0.0e+00	1.8e-06	2.1e-07	0.0e+00
Benzo(a)pyrene	1.0e-06	1.2e-07	0.0e+00	4.5e-07	5.1e-08	0.0e+00
Ideno(1,2,3-cd)pyrene	6.1e-07	7.0e-08	0.0e+00	2.6e-07	3.0e-08	0.0e+00
Dibenz(a,h)anthracene	2.9e-07	3.4e-08	0.0e+00	1.3e-07	1.4e-08	0.0e+00
Benzo(g,h,i)perylene	6.8e-07	7.7e-08	0.0e+00	2.9e-07	3.3e-08	0.0e+00
Total Carcinogenic PAHs	1.3e-05	1.4e-06	0.0e+00	5.4e-06	6.1e-07	0.0e+00
METALS						
Barium	8.4e-05	2.9e-04	0.0e+00	3.6e-05	1.2e-04	0.0e+00
Cadmium (food/soil)	4.7e-07	1.6e-06	0.0e+00	2.0e-07	6.9e-07	0.0e+00
Chromium VI	1.5e-05	5.3e-05	0.0e+00	6.6e-06	2.3e-05	0.0e+00
Copper	1.2e-04	4.1e-04	0.0e+00	5.2e-05	1.8e-04	0.0e+00
Mercury	4.5e-07	1.5e-06	0.0e+00	1.9e-07	6.6e-07	0.0e+00
Nickel	1.1e-05	3.6e-05	0.0e+00	4.5e-06	1.5e-05	0.0e+00
Silver	2.1e-06	7.2e-06	0.0e+00	9.0e-07	3.1e-06	0.0e+00
Zinc	1.4e-04	4.8e-04	0.0e+00	6.0e-05	2.1e-04	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FB-1.w20
3/12/92
JAH/jah/TB/MWK

Table M-10

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Kishwaukee Creek

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Zinc	1.4e-05	2.9e-06	0.0e+00	6.0e-06	1.3e-06	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FC-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-11

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Wetlands

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Arsenic	1.9e-07	3.9e-08	0.0e+00	8.0e-08	1.7e-08	0.0e+00
Barium	1.7e-05	3.6e-06	0.0e+00	7.4e-06	1.5e-06	0.0e+00
Copper	1.1e-06	2.3e-07	0.0e+00	4.6e-07	9.8e-08	0.0e+00
Lead (3)	4.1e-07	8.6e-08	0.0e+00	1.8e-07	3.7e-08	0.0e+00
Manganese	5.0e-05	1.0e-05	0.0e+00	2.1e-05	4.5e-06	0.0e+00
Nickel	1.1e-05	2.3e-06	0.0e+00	4.7e-06	9.8e-07	0.0e+00
Zinc	2.0e-05	4.3e-06	0.0e+00	8.8e-06	1.8e-06	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chronic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

3. The U.S.EPA's lead uptake/biokinetic model was used to estimate lead intakes. Refer to section 8.5.1.2 of the baseline risk assessment for a discussion of this model.

[woodstock.2020.RA]FD-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-12

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Kishwaukee Creek

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Chromium VI	3.7e-06	7.1e-07	0.0e+00	1.6e-06	3.0e-07	0.0e+00
Cobalt	2.1e-07	2.7e-07	0.0e+00	9.1e-08	1.2e-07	0.0e+00
Copper	9.8e-07	1.2e-06	0.0e+00	4.2e-07	5.3e-07	0.0e+00
Nickel	5.8e-06	1.1e-06	0.0e+00	2.5e-06	4.8e-07	0.0e+00
Zinc	1.0e-04	2.0e-05	0.0e+00	4.5e-05	8.6e-06	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FE-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-13

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Wetland

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
VOLATILES						
2-Butanone	9.2e-08	5.9e-10	0.0	3.9e-08	2.5e-10	0.0
Toluene	5.6e-07	3.6e-09	0.0	2.4e-07	1.5e-09	0.0
SEMIVOLATILES						
Phenol	6.8e-06	4.3e-08	0.0	2.9e-06	1.8e-08	0.0
1,2-Dichlorobenzene	6.1e-07	3.9e-09	0.0	2.6e-07	1.7e-09	0.0
4-Methylphenol	1.1e-06	7.0e-09	0.0	4.7e-07	3.0e-09	0.0
Benzoic Acid	1.2e-06	7.4e-09	0.0	5.0e-07	3.2e-09	0.0
Fluoranthene	7.4e-07	4.7e-09	0.0	3.2e-07	2.0e-09	0.0
bis(2-ethylhexyl)phthalate	7.4e-06	4.7e-08	0.0	3.2e-06	2.0e-08	0.0
METALS						
Chromium VI	8.5e-06	1.6e-06	0.0	3.6e-06	6.9e-07	0.0
Copper	2.9e-05	5.6e-06	0.0	1.3e-05	2.4e-06	0.0
Mercury	6.1e-08	1.2e-08	0.0	2.6e-08	5.0e-09	0.0
Nickel	5.6e-05	1.1e-05	0.0	2.4e-05	4.6e-06	0.0
Selenium	5.9e-07	1.1e-07	0.0	2.5e-07	4.8e-08	0.0
Thallium	7.6e-07	1.4e-07	0.0	3.2e-07	6.2e-08	0.0
Zinc	1.6e-04	3.1e-05	0.0	7.1e-05	1.3e-05	0.0

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FF-I.w20
3/10/92
JAH/jah/TB/MWK

Table M-14

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: On-Site Resident
Land Use: Future Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)	CARCINOGENS (mg/kg-d)
	Inhalation	Inhalation
VOLATILES		
Chloroethane	1.4e-05	6.1e-06
Benzene	8.2e-06	3.5e-06
Toluene	5.7e-06	2.4e-06
Chlorobenzene	6.5e-06	2.8e-06
Ethylbenzene	1.6e-05	6.7e-06
Xylenes (mixed)	2.2e-05	9.5e-06
Freon	6.3e-06	2.7e-06
4-Ethyl Toluene	9.1e-06	3.9e-06
1,3,5-Trimethylbenzene	4.0e-06	1.7e-06
1,2,4-Trimethylbenzene	1.8e-05	7.8e-06

(a) Values not available for Freon-114, dichlorodifluoroethane used.
(b) Values for ethyl toluene not available, toluene used instead.
(c) Values for trimethylbenzene not available, toluene used instead.

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FG-I.w20
10/31/91
JAH/jah/TB/MWK

Table M-15

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Soil
Source Area: Landfill

Population: On-Site Resident
Land Use: *Future Use Scenario*

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
SEMIVOLATILES						
4-Chloroaniline	3.1e-06	3.5e-07	0.0	1.3e-06	1.5e-07	0.0
Dimethylphthalate	1.5e-06	1.8e-07	0.0	6.6e-07	7.5e-08	0.0
Phenanthrene	1.2e-06	1.4e-07	0.0	5.2e-07	5.9e-08	0.0
Di-n-butylphthalate	3.7e-06	4.2e-07	0.0	1.6e-06	1.8e-07	0.0
Fluoranthene	3.4e-06	3.9e-07	0.0	1.4e-06	1.7e-07	0.0
Pyrene	4.0e-06	4.6e-07	0.0	1.7e-06	2.0e-07	0.0
Butylbenzylphthalate	4.4e-06	5.1e-07	0.0	1.9e-06	2.2e-07	0.0
Benzo(a)anthracene	2.5e-06	2.8e-07	0.0	1.1e-06	1.2e-07	0.0
Chrysene	2.8e-06	3.2e-07	0.0	1.2e-06	1.4e-07	0.0
Benzo(b)fluoranthene	1.1e-05	1.2e-06	0.0	4.5e-06	5.2e-07	0.0
Benzo(k)fluoranthene	1.1e-05	1.2e-06	0.0	4.5e-06	5.2e-07	0.0
Benzo(a)pyrene	2.6e-06	3.0e-07	0.0	1.1e-06	1.3e-07	0.0
Ideno(1,2,3-cd)pyrene	1.5e-06	1.8e-07	0.0	6.6e-07	7.5e-08	0.0
Dibenz(a,h)anthracene	7.4e-07	8.4e-08	0.0	3.2e-07	3.6e-08	0.0
Benzo(g,h,i)perylene	1.7e-06	1.9e-07	0.0	7.2e-07	8.3e-08	0.0
Total Carcinogenic PAHs	3.1e-05	3.6e-06	0.0	1.3e-05	1.5e-06	0.0
METALS						
Barium	2.1e-04	7.2e-04	0.0	9.0e-05	3.1e-04	0.0
Cadmium (food/soil)	1.2e-06	4.0e-06	0.0	5.0e-07	1.7e-06	0.0
Chromium VI	3.8e-05	1.3e-04	0.0	1.6e-05	5.6e-05	0.0
Copper	3.0e-04	1.0e-03	0.0	1.3e-04	4.4e-04	0.0
Mercury	1.1e-06	3.9e-06	0.0	4.8e-07	1.7e-06	0.0
Nickel	2.6e-05	9.0e-05	0.0	1.1e-05	3.9e-05	0.0
Silver	5.3e-06	1.8e-05	0.0	2.3e-06	7.7e-06	0.0
Zinc	3.5e-04	1.2e-03	0.0	1.5e-04	5.2e-04	0.0

Notes:
1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FH-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-16

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Vegetables
Source Area: Landfill Surface Soil

Population: On-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	*Ingestion*	*Inhalation*	*Dermal Contact*	*Ingestion*	*Inhalation*
SEMIVOLATILES						
4-Chloroaniline	0.0e+00	2.8e-06	0.0e+00	0.0e+00	1.2e-06	0.0e+00
Dimethylphthalate	0.0e+00	1.4e-06	0.0e+00	0.0e+00	6.0e-07	0.0e+00
Phenanthrene	0.0e+00	1.1e-06	0.0e+00	0.0e+00	4.7e-07	0.0e+00
Di-n-butylphthalate	0.0e+00	3.3e-06	0.0e+00	0.0e+00	1.4e-06	0.0e+00
Fluoranthene	0.0e+00	3.1e-06	0.0e+00	0.0e+00	1.3e-06	0.0e+00
Pyrene	0.0e+00	3.6e-06	0.0e+00	0.0e+00	1.6e-06	0.0e+00
Butylbenzylphthalate	0.0e+00	4.0e-06	0.0e+00	0.0e+00	1.7e-06	0.0e+00
Benzo(a)anthracene	0.0e+00	2.2e-06	0.0e+00	0.0e+00	9.5e-07	0.0e+00
Chrysene	0.0e+00	2.5e-06	0.0e+00	0.0e+00	1.1e-06	0.0e+00
Benzo(b)fluoranthene	0.0e+00	9.6e-06	0.0e+00	0.0e+00	4.1e-06	0.0e+00
Benzo(k)fluoranthene	0.0e+00	9.6e-06	0.0e+00	0.0e+00	4.1e-06	0.0e+00
Benzo(a)pyrene	0.0e+00	2.4e-06	0.0e+00	0.0e+00	1.0e-06	0.0e+00
Ideno(1,2,3-cd)pyrene	0.0e+00	1.4e-06	0.0e+00	0.0e+00	6.0e-07	0.0e+00
Dibenz(a,h)anthracene	0.0e+00	6.7e-07	0.0e+00	0.0e+00	2.9e-07	0.0e+00
Benzo(g,h,i)perylene	0.0e+00	1.5e-06	0.0e+00	0.0e+00	6.6e-07	0.0e+00
Total Carcinogenic PAHs	0.0e+00	2.8e-05	0.0e+00	0.0e+00	1.2e-05	0.0e+00
METALS						
Barium	0.0e+00	2.5e-02	0.0e+00	0.0e+00	1.1e-02	0.0e+00
Cadmium (food/soil)	0.0e+00	1.4e-04	0.0e+00	0.0e+00	5.9e-05	0.0e+00
Chromium VI	0.0e+00	5.8e-05	0.0e+00	0.0e+00	2.5e-05	0.0e+00
Copper	0.0e+00	2.2e-02	0.0e+00	0.0e+00	9.5e-03	0.0e+00
Mercury	0.0e+00	2.1e-05	0.0e+00	0.0e+00	8.9e-06	0.0e+00
Nickel	0.0e+00	3.8e-03	0.0e+00	0.0e+00	1.6e-03	0.0e+00
Silver	0.0e+00	6.1e-04	0.0e+00	0.0e+00	2.6e-04	0.0e+00
Zinc	0.0e+00	1.2e-02	0.0e+00	0.0e+00	5.3e-03	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FI-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-17

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Leachate as Groundwater
Source Area: Landfill

Population: On-Site resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	*Ingestion*	*Inhalation*	*Dermal Contact*	*Ingestion*	*Inhalation*
VOLATILES						
1,2-Dichloroethene (trans)	9.5e-05	5.2e-04	2.2e-04	4.1e-05	2.2e-04	9.6e-05
Benzene	9.2e-06	4.6e-04	2.0e-04	3.9e-06	2.0e-04	8.4e-05
Toluene	1.2e-05	6.5e-05	2.8e-05	5.1e-06	2.8e-05	1.2e-05
Chlorobenzene	4.8e-05	2.6e-04	1.1e-04	2.0e-05	1.1e-04	4.8e-05
Xylenes (mixed)	4.7e-06	2.6e-04	1.1e-04	2.0e-06	1.1e-04	4.8e-05
SEMIVOLATILES						
1,4-Dichlorobenzene	1.2e-06	2.6e-04	6.2e-05	5.1e-07	1.1e-04	2.7e-05
4-Methylphenol	1.0e-06	6.5e-05	1.6e-05	4.4e-07	2.8e-05	6.7e-06
Benzoic Acid	8.0e-06	1.8e-03	4.2e-04	3.4e-06	7.5e-04	1.8e-04
Naphthalene	5.0e-06	1.1e-03	2.7e-04	2.1e-06	4.7e-04	1.1e-04
Pentachlorophenol	4.4e-07	9.8e-05	2.3e-05	1.9e-07	4.2e-05	1.0e-05
METALS						
Antimony	2.7e-06	9.8e-04	0.0e+00	1.1e-06	4.2e-04	0.0e+00
Arsenic	9.0e-06	3.3e-03	0.0e+00	3.9e-06	1.4e-03	0.0e+00
Barium	9.6e-04	3.5e-01	0.0e+00	4.1e-04	1.5e-01	0.0e+00
Beryllium	2.1e-06	7.6e-04	0.0e+00	8.9e-07	3.3e-04	0.0e+00
Cadmium (water)	2.9e-05	1.1e-02	0.0e+00	1.3e-05	4.6e-03	0.0e+00
Chromium VI	1.7e-04	4.6e-02	0.0e+00	7.4e-05	2.0e-02	0.0e+00
Cobalt	4.8e-05	1.8e-02	0.0e+00	2.1e-05	7.6e-03	0.0e+00
Copper	9.6e-04	3.5e-01	0.0e+00	4.1e-04	1.5e-01	0.0e+00
Lead	1.6e-03	5.9e-01	0.0e+00	6.8e-04	2.5e-01	0.0e+00
Manganese	2.8e-03	1.0e+00	0.0e+00	1.2e-03	4.3e-01	0.0e+00
Mercury	5.0e-07	1.9e-04	0.0e+00	2.2e-07	7.9e-05	0.0e+00
Nickel	1.3e-03	4.9e-01	0.0e+00	5.7e-04	2.1e-01	0.0e+00
Selenium	1.8e-06	6.7e-04	0.0e+00	7.8e-07	2.9e-04	0.0e+00
Silver	5.1e-06	1.9e-03	0.0e+00	2.2e-06	8.1e-04	0.0e+00
Thallium	1.4e-06	5.0e-04	0.0e+00	5.8e-07	2.1e-04	0.0e+00
Vanadium	1.2e-04	4.3e-02	0.0e+00	5.0e-05	1.8e-02	0.0e+00
Zinc	1.6e-02	6.0e+00	0.0e+00	7.0e-03	2.6e+00	0.0e+00
Cyanide	5.3e-06	2.0e-03	0.0e+00	2.3e-06	8.4e-04	0.0e+00

Notes:
1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for carcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FJ-I.w20
3/10/92
JAH/jah/TB/MWK

Table M-18

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Kishwaukee Creek

Population: On-Site resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Zinc	2.4e-05	5.0e-06	0.0	1.0e-05	2.2e-06	0.0

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FK-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-19

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Wetlands

Population: On-Site resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Arsenic	3.2e-07	6.7e-08	0.0	1.4e-07	2.9e-08	0.0
Barium	2.9e-05	6.2e-06	0.0	1.3e-05	2.7e-06	0.0
Copper	1.9e-06	3.9e-07	0.0	8.0e-07	1.7e-07	0.0
Lead (3)	7.0e-07	1.5e-07	0.0	3.0e-07	6.3e-08	0.0
Manganese	8.5e-05	1.8e-05	0.0	3.6e-05	7.7e-06	0.0
Nickel	1.9e-05	3.9e-06	0.0	8.0e-06	1.7e-06	0.0
Zinc	3.5e-05	7.4e-06	0.0	1.5e-05	3.2e-06	0.0

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chronic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

3. The U.S.EPA's lead uptake/biokinetic model was used to estimate lead intakes. Refer to section 8.5.1.2 of the baseline risk assessment for a discussion of this model.

[woodstock.2020.RA]FL-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-20

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Kishwaukee Creek

Population: On-Site resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Chromium VI	6.4e-06	1.2e-06	0.0	2.7e-06	5.2e-07	0.0
Cobalt	3.6e-07	4.6e-07	0.0	1.6e-07	2.0e-07	0.0
Copper	1.7e-06	2.1e-06	0.0	7.2e-07	9.1e-07	0.0
Nickel	1.0e-05	1.9e-06	0.0	4.3e-06	8.2e-07	0.0
Zinc	1.8e-04	3.4e-05	0.0	7.7e-05	1.5e-05	0.0

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FM-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-21

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Wetands

Population: On-Site resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
VOLATILES						
2-Butanone	2.3e-07	1.5e-09	0.0	9.9e-08	6.3e-10	0.0
Toluene	1.4e-06	9.0e-09	0.0	6.0e-07	3.8e-09	0.0
SEMIVOLATILES						
Phenol	1.7e-05	1.1e-07	0.0	7.2e-06	4.6e-08	0.0
1,2-Dichlorobenzene	1.5e-06	9.8e-09	0.0	6.6e-07	4.2e-09	0.0
4-Methylphenol	2.8e-06	1.8e-08	0.0	1.2e-06	7.5e-09	0.0
Benzoic Acid	2.9e-06	1.9e-08	0.0	1.2e-06	7.9e-09	0.0
Fluoranthene	1.8e-06	1.2e-08	0.0	7.9e-07	5.0e-09	0.0
bis(2-ethylhexyl)phthalate	1.8e-05	1.2e-07	0.0	7.9e-06	5.0e-08	0.0
METALS						
Chromium VI	2.1e-05	4.0e-06	0.0	9.1e-06	1.7e-06	0.0
Copper	7.4e-05	1.4e-05	0.0	3.2e-05	6.0e-06	0.0
Mercury	1.5e-07	2.9e-08	0.0	6.6e-08	1.3e-08	0.0
Nickel	1.4e-04	2.7e-05	0.0	6.0e-05	1.1e-05	0.0
Selenium	1.5e-06	2.8e-07	0.0	6.4e-07	1.2e-07	0.0
Thallium	1.9e-06	3.6e-07	0.0	8.1e-07	1.5e-07	0.0
Zinc	4.1e-04	7.9e-05	0.0	1.8e-04	3.4e-05	0.0

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FN-I.w20
3/10/92
JAH/jah/TB/MWK

Table M-22

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Indoor Air
Source Area: Landfill Gas

Population: On-Site Resident
Land Use: Future Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)	CARCINOGENS (mg/kg-d)
	Inhalation	Inhalation
VOLATILES		
Chloroethane	4.2e-02	1.8e-02
Benzene	2.4e-02	1.0e-02
Toluene	1.7e-02	7.1e-03
Chlorobenzene	1.9e-02	8.1e-03
Ethylbenzene	4.6e-02	2.0e-02
Xylenes (mixed)	6.5e-02	2.8e-02
Freon	1.9e-02	7.9e-03
4-Ethyl Toluene	2.7e-02	1.1e-02
1,3,5-Trimethylbenzene	1.2e-02	5.1e-03
1,2,4-Trimethylbenzene	5.4e-02	2.3e-02

(a) Values not available for Freon-114, dichlorodifluoroethane used.
(b) Values for ethyl toluene not available, toluene used instead.
(c) Values for trimethylbenzene not available, toluene used instead.

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FS-I.w20
6/10/92
JAH/jah/TB/MWK

Table M-23

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: Off-Site Resident
Land Use: Future Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)	CARCINOGENS (mg/kg-d)
	Inhalation	Inhalation
VOLATILES		
Chloroethane	1.4e-05	6.1e-06
Benzene	8.2e-06	3.5e-06
Toluene	5.7e-06	2.4e-06
Chlorobenzene	6.5e-06	2.8e-06
Ethylbenzene	1.6e-05	6.7e-06
Xylenes (mixed)	2.2e-05	9.5e-06
Freon	6.3e-06	2.7e-06
4-Ethyl Toluene	9.1e-06	3.9e-06
1,3,5-Trimethylbenzene	4.0e-06	1.7e-06
1,2,4-Trimethylbenzene	1.8e-05	7.8e-06

(a) Values not available for Freon-114, dichlorodifluoroethane used.
(b) Values for ethyl toluene not available, toluene used instead.
(c) Values for trimethylbenzene not available, toluene used instead.

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FO-1.w20
10/31/91
JAH/jah/TB/MWK

Table M-24

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Groundwater
Source Area: Upper Aquifer

Population: Off-Site resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
VOLATILES						
Vinyl chloride	1.3e-04	6.8e-04	2.9e-04	5.4e-05	2.9e-04	1.3e-04
Acetone	3.0e-05	1.6e-04	7.0e-05	1.3e-05	7.0e-05	3.0e-05
1,2-Dichloroethene (trans)	1.8e-05	9.8e-05	4.2e-05	7.7e-06	4.2e-05	1.8e-05
Benzene	2.6e-06	1.3e-04	5.6e-05	1.1e-06	5.6e-05	2.4e-05
SEMIVOLATILES						
bis(2-ethylhexyl)phthalate	8.4e-10	1.6e-04	3.9e-05	3.6e-10	7.0e-05	1.7e-05
METALS						
Antimony	6.0e-07	2.2e-04	0.0e+00	2.6e-07	9.5e-05	0.0e+00
Arsenic	1.7e-06	6.2e-04	0.0e+00	7.3e-07	2.7e-04	0.0e+00
Vanadium	5.0e-07	1.8e-04	0.0e+00	2.1e-07	7.8e-05	0.0e+00
Cyanide	1.2e-06	4.2e-04	0.0e+00	4.9e-07	1.8e-04	0.0e+00

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FP-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-25

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Kishwaukee Creek

Population: Off-Site resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Zinc	2.4e-05	1.0e-05	0.0	1.0e-05	4.3e-06	0.0

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FQ-I.w20
6/8/92
JAH/jah/TB/MWK

Table M-26

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Kishwaukee Creek

Population: Off-Site resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
METALS						
Chromium VI	6.4e-06	2.4e-06	0.0	2.7e-06	1.0e-06	0.0
Cobalt	3.6e-07	9.2e-07	0.0	1.6e-07	4.0e-07	0.0
Copper	1.7e-06	4.3e-06	0.0	7.2e-07	1.8e-06	0.0
Nickel	1.0e-05	3.8e-06	0.0	4.3e-06	1.6e-06	0.0
Zinc	1.8e-04	6.9e-05	0.0	7.7e-05	2.9e-05	0.0

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

[woodstock.2020.RA]FR-I.w20
3/12/92
JAH/jah/TB/MWK

Table M-27

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Leachate
Source Area: Groundwater

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	NONCARCINOGENS (mg/kg-d)			CARCINOGENS (mg/kg-d)		
	Dermal Contact	Ingestion	Inhalation	Dermal Contact	Ingestion	Inhalation
VOLATILES						
1,2-Dichloroethene (trans)	0.0e+00	5.2e-05	0.0e+00	0.0e+00	2.2e-05	0.0e+00
Benzene	0.0e+00	4.6e-05	0.0e+00	0.0e+00	2.0e-05	0.0e+00
Toluene	0.0e+00	6.5e-06	0.0e+00	0.0e+00	2.8e-06	0.0e+00
Chlorobenzene	0.0e+00	2.6e-05	0.0e+00	0.0e+00	1.1e-05	0.0e+00
Xylenes (mixed)	0.0e+00	2.6e-05	0.0e+00	0.0e+00	1.1e-05	0.0e+00
SEMIVOLATILES						
1,4-Dichlorobenzene	0.0e+00	2.6e-05	0.0e+00	0.0e+00	1.1e-05	0.0e+00
4-Methylphenol	0.0e+00	6.5e-06	0.0e+00	0.0e+00	2.8e-06	0.0e+00
Benzoic Acid	0.0e+00	1.8e-04	0.0e+00	0.0e+00	7.5e-05	0.0e+00
Naphthalene	0.0e+00	1.1e-04	0.0e+00	0.0e+00	4.7e-05	0.0e+00
Pentachlorophenol	0.0e+00	9.8e-06	0.0e+00	0.0e+00	4.2e-06	0.0e+00
METALS						
Antimony	0.0e+00	9.8e-05	0.0e+00	0.0e+00	4.2e-05	0.0e+00
Arsenic	0.0e+00	3.3e-04	0.0e+00	0.0e+00	1.4e-04	0.0e+00
Barium	0.0e+00	3.5e-02	0.0e+00	0.0e+00	1.5e-02	0.0e+00
Beryllium	0.0e+00	7.6e-05	0.0e+00	0.0e+00	3.3e-05	0.0e+00
Cadmium (water)	0.0e+00	1.1e-03	0.0e+00	0.0e+00	4.6e-04	0.0e+00
Chromium VI	0.0e+00	4.6e-03	0.0e+00	0.0e+00	2.0e-03	0.0e+00
Cobalt	0.0e+00	1.8e-03	0.0e+00	0.0e+00	7.6e-04	0.0e+00
Copper	0.0e+00	3.5e-02	0.0e+00	0.0e+00	1.5e-02	0.0e+00
Lead	0.0e+00	5.9e-02	0.0e+00	0.0e+00	2.5e-02	0.0e+00
Manganese	0.0e+00	1.0e-01	0.0e+00	0.0e+00	4.3e-02	0.0e+00
Mercury	0.0e+00	1.9e-05	0.0e+00	0.0e+00	7.9e-06	0.0e+00
Nickel	0.0e+00	4.9e-02	0.0e+00	0.0e+00	2.1e-02	0.0e+00
Selenium	0.0e+00	6.7e-05	0.0e+00	0.0e+00	2.9e-05	0.0e+00
Silver	0.0e+00	1.9e-04	0.0e+00	0.0e+00	8.1e-05	0.0e+00
Thallium	0.0e+00	5.0e-05	0.0e+00	0.0e+00	2.1e-05	0.0e+00
Vanadium	0.0e+00	4.3e-03	0.0e+00	0.0e+00	1.8e-03	0.0e+00
Zinc	0.0e+00	6.0e-01	0.0e+00	0.0e+00	2.6e-01	0.0e+00
Cyanide	0.0e+00	2.0e-04	0.0e+00	0.0e+00	8.4e-05	0.0e+00

Table M-27

CHRONIC DAILY INTAKE AND ABSORBED DOSE ESTIMATES

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Notes:

1. Absorbed doses were calculated for dermal contact with the medium, and intakes were calculated for ingestion of the medium.

2. For noncarcinogenic effects, the chromic daily intake (CDI) is averaged over the exposure period; whereas for carcinogenic effects, the CDI is averaged over a lifetime (i.e., 70 years). Therefore, the difference between the CDI for noncarcinogenic vs. carcinogenic effects is due to the different methods of time weighting used to estimate the value.

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APPENDIX N

MODELING OF VOLATILE ORGANIC EMISSIONS

APPENDIX N

MODELING OF VOLATILE ORGANIC EMISSIONS FROM LANDFILL GAS WOODSTOCK LANDFILL RI/FS SITE

Volatile organic compounds present in landfill gas at the Woodstock Landfill Site may travel to the surface and be emitted to the atmosphere causing contamination of air at the Site. The extent of this contamination was evaluated by modeling emissions of VOCs contained in landfill gas based on Site conditions. The following is a discussion of the models used to assess chemical emissions from the Site and their dispersion to potential receptors located off-Site.

COMPOUND-SPECIFIC MODELED EMISSION RATE

The modeled impact for each pollutant was estimated using the modified Thibodeaux model for landfills with internal gas generation, presented in Superfund Exposure Assessment Manual (SEAM), U.S.EPA/540/1-88/001, Section 2.3.1.2(2). This model provides a means of conservatively estimating emissions from the available Site specific data.

The biological generation of landfill gas creates an upward movement, or convective sweep, of contaminants present in the soil vapor phase. This convective sweep greatly accelerates the upward migration and subsequent release of contaminants to the atmosphere. Contributions from soil and gas diffusion are considered insignificant compared to the convective sweep effect of this biogas generation. Results from this model closely approximate those generated using the original Thibodeaux model that included contributions from these other sources.

The accuracy of the model output is limited by the accuracy of the assumed value for the mean landfill gas velocity in the soil pore spaces. For example, the effect of soil moisture on landfill gas velocity is not accounted for, and may limit the accuracy of the model in predicting emissions of soluble gases. This model assumed dry conditions at the Site. If moist or wet conditions cccur over most of the year, this model conservatively over estimates chemical emissions of water soluble chemicals.

The following equation is used to estimate compound-specific emission rates:

$$E_i = C_i * V_y$$

where:

E_i = Emission rate of compound i (ug/m^2-sec)

C_i = Concentration of compound i in the soil pore spaces (ug/m^3)

V_y = Mean landfill gas velocity in the soil pore spaces (m/sec)

C_i, the concentration of compound i in the soil pore spaces, is taken to be the maximum detected concentration of compound i, from the November 1990 landfill gas sampling round. Analytical results were reported as part-per-billion, volume to volume (ppb v/v or ppbv). These results were converted to units of ug/m^3 (w/v) using the following formula, presented in the SOP for the determination of VOCs in Ambient Air (Woodstock QAPP, April 1990, Appendix F, page 18 of 22):

$$C_i * \frac{MW_i}{24.5} = ng/L$$

where:

C_i = concentration of compound i in landfill gas (ppb v/v)
MW_i = molecular weight of compound i

Results in ng/L are then converted to ug/m^3 as follows:

$$(ng/L) * (1\ ug / 1000\ ng) * (1000\ L / 1\ m^3) = ug/m^3$$

V_y, the mean landfill gas velocity in the soil pore spaces, was not determined at the Site. The model provides an estimate of landfill gas velocity (i.e., 1.63e-05 m/sec). This estimate was used to model emission for the Site and likely over estimates the Site's actual landfill gas emission rate, based on the low (i.e., <2%) gas content measured in leachate headwells.

This model, as presented in SEAM, includes a expression for the surface area of the Landfill. This expression has been dropped from the equation, because the landfill's surface area is included in the ISCLT model. The chemical specific emission rates units have been appropriately changed to fit the ISCLT model requirements (i.e., ug/m^2-sec).

DISPERSION MODELING

The Industrial Source Complex Long-Term model (ISCLT) has been used to characterize the long-term impacts on ambient air quality surrounding the Woodstock Landfill as a result of releases of landfill gas containing VOCs. The ISCLT model was developed under the auspices of the U.S. EPA. Model version number 90008 was used, which is currently promulgated for regulatory purposes.

Many of the model inputs used were regulatory default options. These options generally result in a conservative (i.e., high) estimate of contaminant air concentrations. Rural dispersion coefficients were implemented based on the low population density in the vicinity of the Site. No adjustment was made to account for minor variations in topography, since the landfill surface elevation exceeds that the elevation of most of the area surrounding the landfill.

The ISCLT model requires a statistical summary (STAR format) of hourly meteorological data (e.g., wind speed, direction, etc.) as an input. In this study, a meteorological data set collected over a five year period (1966-1970) from the National Weather Service (NWS) station in Rockford, Illinois was processed into this format. Ambient temperatures and mixing heights were averaged over this period for each meteorological stability class. The wind instruments at the Rockford, Illinois NWS were located 6.1 meters above the ground surface during the five year period data was collected.

Wind direction was grouped into 16 sectors of 22.5 degrees each. Wind speeds were grouped into classes of speed conforming to the six wind speed classes which are defaults of the ISCLT model. Hours during which calm winds were recorded were distributed over the two lower wind speed classes by standard methods, and the data set was then renormalized.

The wind rose (refer to Figure N-1) was drawn combining all stability class data into an array by wind speed and direction. It otherwise represents meteorological data used to model air impacts at the Site.

The landfill was modeled as a single, square area source. The landfill was approximated as being 1250 feet (381.1 meters) on each side. The northwest corner of the square used to represent the landfill was located close (0.55 meters west, 0.55 meters north) to the origin of the project geophysical grid. This was done to insure the symmetry of the receptor grid. The height of the area source was modeled as 0.1 meter above ground level.

The air dispersion model calculates air chemical concentrations at predetermined locations which are input into the model. Each location has both an x and y coordinate. The x model coordinates (coordinates) represents the direction either east (positive (+) x coordinate) or west (negative (-) coordinate) of the landfill, while the y coordinates represent the direction either north (postive y (+) coordinate) or south (negative (-) y coordinate) of the landfill. These locations are referred to as receptors. Receptors were located on a regular grid with 100 meter spacing. This grid was centered on the center of the modeled landfill in order to minimize the biasing of impacts due to differences in the distance-to-receptor. Since the model will not calculate impacts for receptors located within the area source (landfill), these receptors show zero as a concentration in the model output (refer to page 7 of Attachment 1). The closest receptors are located 9.45 meters from the boundary of the modeled landfill. A map of the source area (landfill) and receptors is included (refer to Figure N-2).

The landfill was approximated by a single square area source to be able to model a unit chemical emission rate of 1 ug per meter squared per sec (1 ug/m^2-sec). The modeled air chemical concentrations, based on the unit emission rate, at each receptor location were output in micrograms per cubic meter (ug/m^3)(Refer to page 7 of the Attachment 1). To calculate the chemical specific air concentration at a receptor location, the unit concentration (U_c) at the receptor was multiplied by the ratio of the chemical specific emission rate over the unit emission rate (1 ug/m^2-sec). In this way, the concentration of each chemical at a receptor location is calculated based on their respective concentration in landfill gas.

The following is the equation used to calculate chemical specific air concentrations at a receptor location.

$$R_c\,(x,y) = U_c\,(x,y) \cdot \frac{E_i}{E_u}$$

where:

$R_c\,(x,y)$ = Air concentration for chemical i at the receptor with coordinates x and y, (ug/m^3)

$U_c\,(x,y)$ = Unit concentration at the receptor with coordinates x and y, (ug/m^3; refer to page 7 of Attachment 1)

E_u = Unit emission rate (1 ug/m^2 - sec)

E_i = Chemical specific emission rate (ug/m^2 - sec; refer to Table N-1).

These modeled air chemical concentrations were used in the Baseline Risk Assessment (BRA) to calculate human health risks associated with inhalation of VOCs.

The maximum air quality impacts are to be expected due north of the Landfill center (coordinates 190,10) at the landfill boundary. Because this location provides the highest unit chemical air concentrations, air impacts in this area were used to calculate the chemical specific air concentrations which are utilized in the BRA.

Table N-1

BASELINE EMISSION AND DOWNWIND CONCENTRATION ESTIMATES FOR LANDFILL GAS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

COMPOUND	MW g/mole	Ci ppb v/v	Ci ug/m3	Ei ug/m2-sec	Rc mg/m3
Chloroethane	64	4.70e+02	1.23e+03	2.00e-02	4.41e-05
Benzene	78	2.20e+02	7.00e+02	1.14e-02	2.51e-05
Toluene	92	1.30e+02	4.88e+02	7.96e-03	1.75e-05
Chlorobenzene	113	1.20e+02	5.53e+02	9.02e-03	1.99e-05
Ethylbenzene	106	3.10e+02	1.34e+03	2.19e-02	4.82e-05
Total Xylenes	106	4.40e+02	1.90e+03	3.10e-02	6.83e-05
Freon 114	171	7.80e+01	5.44e+02	8.87e-03	1.95e-05
4-Ethyl toluene	120	1.60e+02	7.84e+02	1.28e-02	2.81e-05
1,3,5-Trimethylbenzene	120	7.00e+01	3.43e+02	5.59e-03	1.23e-05
1,2,4-Trimethylbenzene	120	3.20e+02	1.57e+03	2.55e-02	5.63e-05

Ei = Ci * Vy
  where
Ei = Emission rate (ug/m2-sec)
Ci = Concentration of compound i (ug/m3)
Vy = mean landfill gas velocity (1.63e-05 m/sec)

To convert analytical results from ppbv to ug/m3:
    ppbv * (MW/24.5)= ng/L
    ng/L * (1 ug / 1000 ng) (1000 L / 1 m3) = ug/m3

Rc = Uc * (Ei / Eu) * Cf
  where
Rc = Receptor concentration (mg/m3)
Uc = Unit concentration (2.202631 ug/m3 at x,y coordinates (190,10); due north of Landfill)
Ei = Chemical specific emission rate (ug/m2-sec)
Eu = Unit emission rate (1 ug/m2-sec)
Cf = Conversion factor (1 mg/1000 ug)

Ei modified from the Superfund Exposure Assessment Manual (SEAM), EPA/540/1-88/001, Sect. 2.3.2.1(2).
Rc from the Industrial Source Complex Long-Term model (ISCLT), version 90008.

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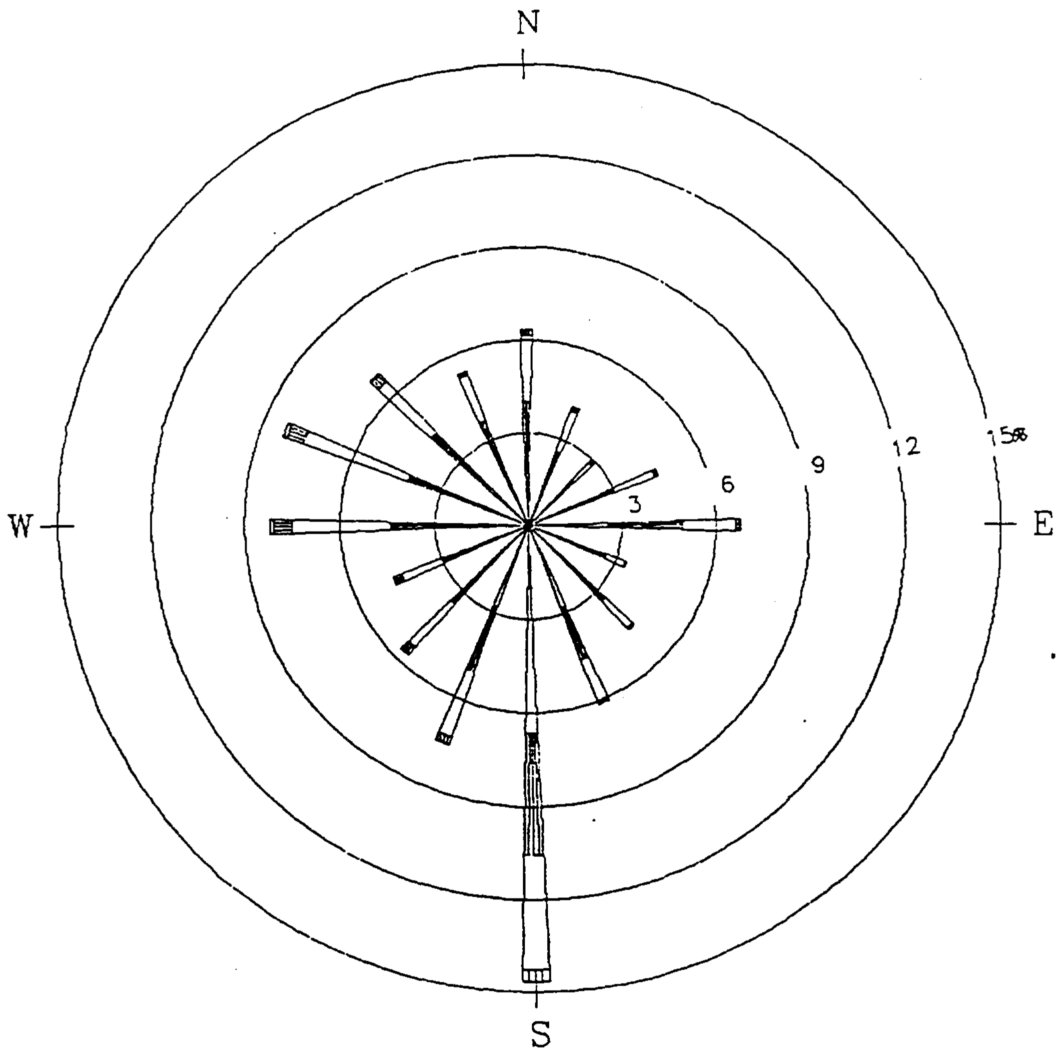
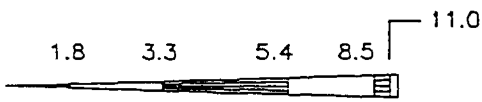
FIGURE N-1





WIND SPEED CLASS BOUNDARIES
(METERS/SECOND)

NOTES:
DIAGRAM OF THE FREQUENCY OF OCCURRENCE FOR EACH WIND DIRECTION. WIND DIRECTION IS THE DIRECTION FROM WHICH THE WIND IS BLOWING. EXAMPLE – WIND IS BLOWING FROM THE NORTH 6.4 PERCENT OF THE TIME.

WINDROSE

STATION NO. 94822
ROCKFORD, IL
PERIOD: 1966–1970

model coordinates are positive to the North + East
geophysical grid coordinates are positive to the South + East

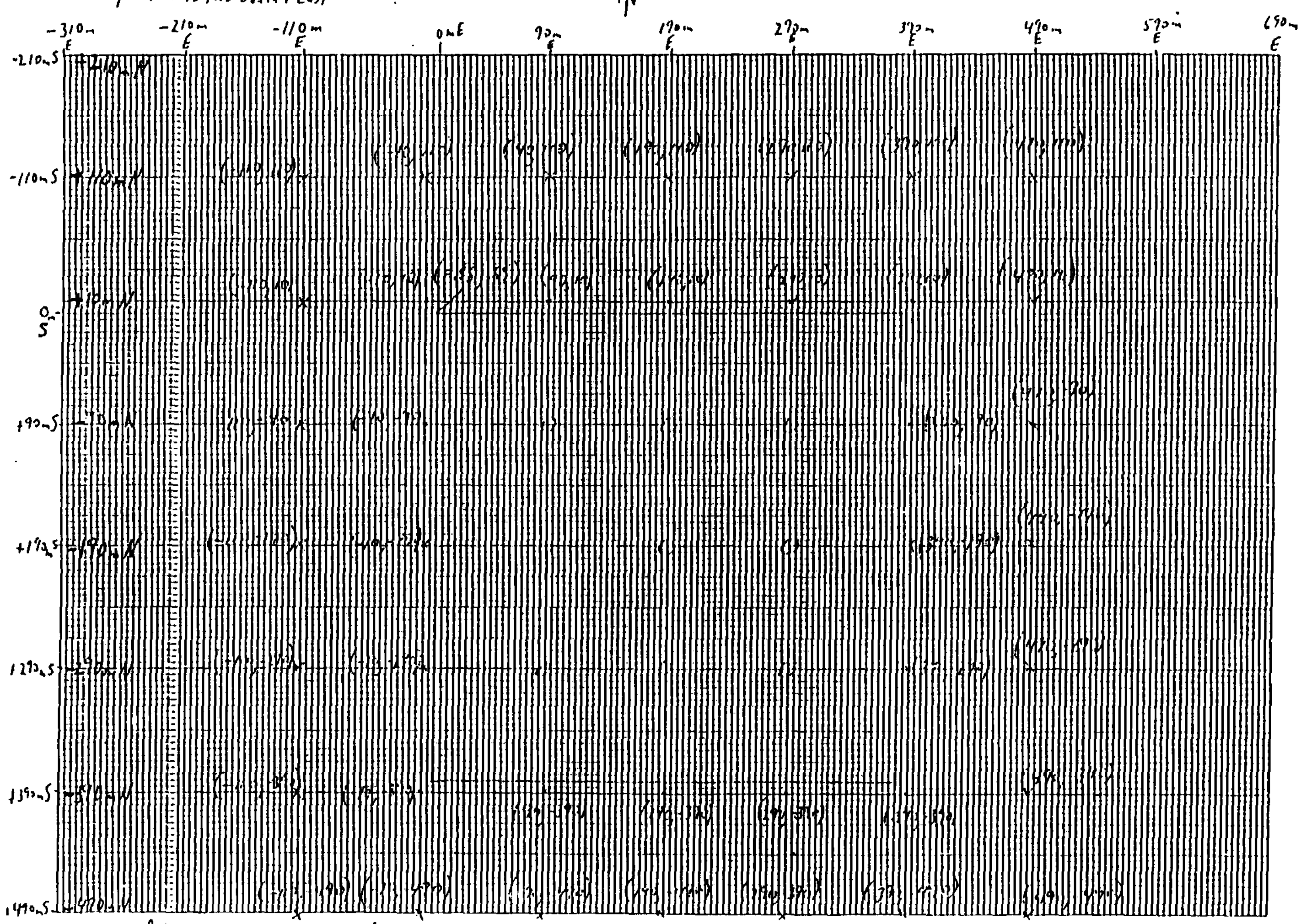
FIGURE N-2

RECEPTOR GRID USED TO MODEL AIR IMPACTS

K+E 20 X 20 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO.

46 1242

Scale: 1 inch = 100m

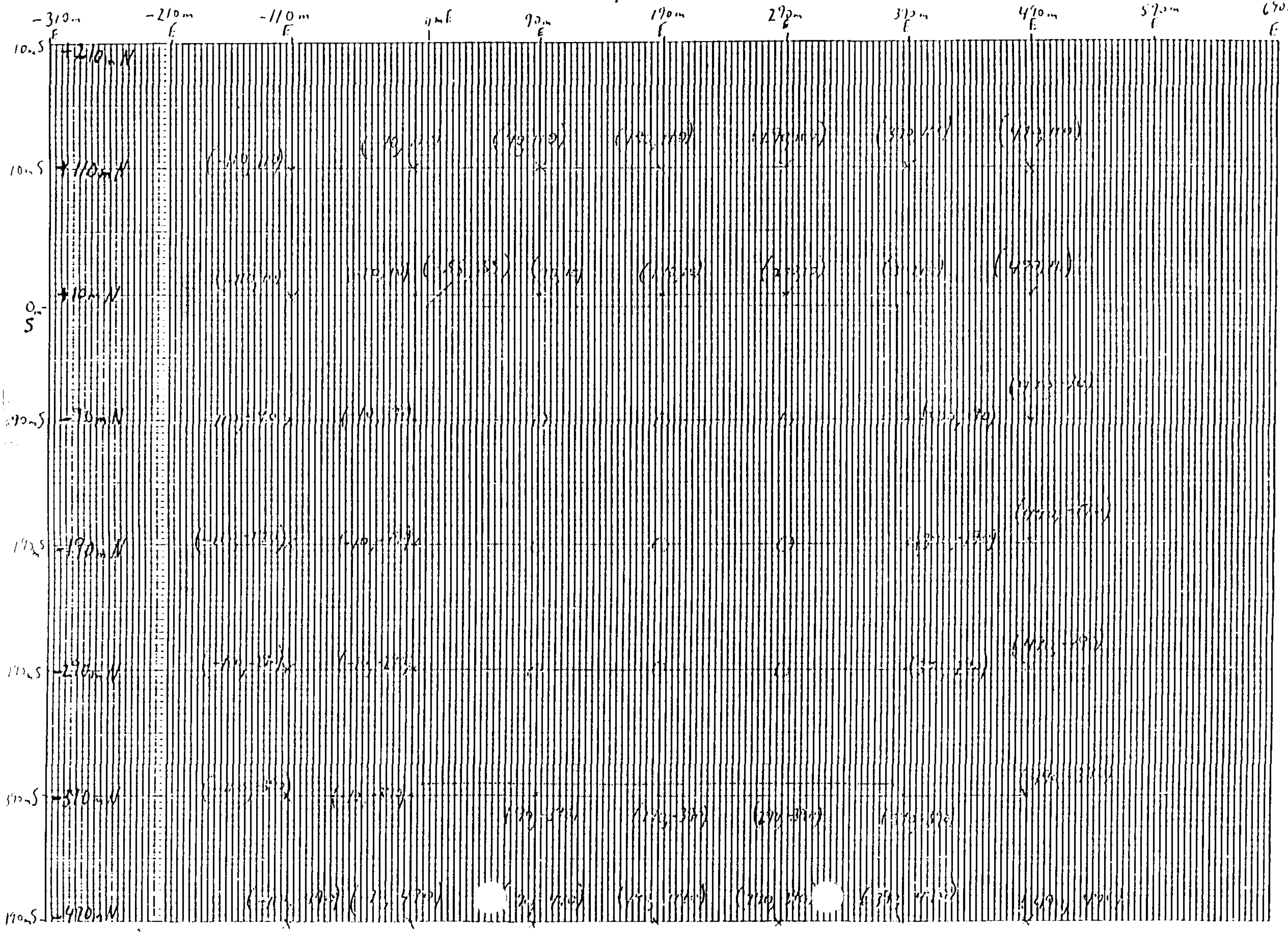


Revised + enlarged map of source + proximal receptors geophysical grid coordinates are positive to the South & East

K+E 20 X 20 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

N Scale: 1 inch = 100m

46 1242



Attachment 1

ISCLT Air Dispersion Model Input and Output

- ISCLT INPUT DATA -

```
NUMBER OF SOURCES =    1
NUMBER OF X AXIS GRID SYSTEM POINTS =   13
NUMBER OF Y AXIS GRID SYSTEM POINTS =   13
NUMBER OF SPECIAL POINTS =    0
NUMBER OF SEASONS =    1
NUMBER OF WIND SPEED CLASSES =    6
NUMBER OF STABILITY CLASSES =    6
NUMBER OF WIND DIRECTION CLASSES =  16
FILE NUMBER OF DATA FILE USED FOR REPORTS =    1
THE PROGRAM IS RUN IN RURAL MODE
CONCENTRATION (DEPOSITION) UNITS CONVERSION FACTOR = .10000000E+07
ACCELERATION OF GRAVITY (METERS/SEC**2) =  9.800
HEIGHT OF MEASUREMENT OF WIND SPEED (METERS) =    6.100
CORRECTION ANGLE FOR GRID SYSTEM VERSUS DIRECTION DATA NORTH (DEGREES) =    .000
DECAY COEFFICIENT = .00000000E+00
PROGRAM OPTION SWITCHES = 1, 1, 1, 0, 0, 3, 2, 1, 3, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0,
DISTANCE X AXIS GRID SYSTEM POINTS (METERS )=    -410.00,    -310.00,    -210.00,    -110.00,    -10.00,     90.00,
     190.00,     290.00,     390.00,     490.00,     590.00,     690.00,     790.00,
DISTANCE Y AXIS GRID SYSTEM POINTS (METERS )=    -790.00,    -690.00,    -590.00,    -490.00,    -390.00,    -290.00,
    -190.00,     -90.00,      10.00,     110.00,     210.00,     310.00,     410.00,
```

- AMBIENT AIR TEMPERATURE (DEGREES KELVIN) -

	STABILITY CATEGORY 1	STABILITY CATEGORY 2	STABILITY CATEGORY 3	STABILITY CATEGORY 4	STABILITY CATEGORY 5	STABILITY CATEGORY 6
SEASON 1	287.0000	287.0000	287.0000	282.9000	278.8000	278.8000

- MIXING LAYER HEIGHT (METERS) -

SEASON 1

	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
STABILITY CATEGORY 1	.190800E+04	.190800E+04	.190800E+04	.190800E+04	.190800E+04	.190800E+04
STABILITY CATEGORY 2	.127200E+04	.127200E+04	.127200E+04	.127200E+04	.127200E+04	.127200E+04
STABILITY CATEGORY 3	.127200E+04	.127200E+04	.127200E+04	.127200E+04	.127200E+04	.127200E+04
STABILITY CATEGORY 4	.127200E+04	.127200E+04	.127200E+04	.127200E+04	.127200E+04	.127200E+04
STABILITY CATEGORY 5	.100000E+05	.100000E+05	.100000E+05	.100000E+05	.100000E+05	.100000E+05
STABILITY CATEGORY 6	.100000E+05	.100000E+05	.100000E+05	.100000E+05	.100000E+05	.100000E+05

- ISCLT INPUT DATA (CONT.) -

- FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY -

SEASON 1

STABILITY CATEGORY 1

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.5000MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00012001	.00007000	.00000000	.00000000	.00000000	.00000000
22.500	.00012001	.00007000	.00000000	.00000000	.00000000	.00000000
45.000	.00012001	.00007000	.00000000	.00000000	.00000000	.00000000
67.500	.00009001	.00000000	.00000000	.00000000	.00000000	.00000000
90.000	.00014001	.00014001	.00000000	.00000000	.00000000	.00000000
112.500	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
135.000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
157.500	.00005000	.00014001	.00000000	.00000000	.00000000	.00000000
180.000	.00005000	.00014001	.00000000	.00000000	.00000000	.00000000
202.500	.00002000	.00007000	.00000000	.00000000	.00000000	.00000000
225.000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
247.500	.00014001	.00014001	.00000000	.00000000	.00000000	.00000000
270.000	.00012001	.00034002	.00000000	.00000000	.00000000	.00000000
292.500	.00002000	.00007000	.00000000	.00000000	.00000000	.00000000
315.000	.00005001	.00000000	.00000000	.00000000	.00000000	.00000000
337.500	.00014001	.00014001	.00000000	.00000000	.00000000	.00000000

SEASON 1

STABILITY CATEGORY 2

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.5000MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00074004	.00144009	.00062004	.00000000	.00000000	.00000000
22.500	.00019001	.00068004	.00027002	.00000000	.00000000	.00000000
45.000	.00056003	.00082005	.00014001	.00000000	.00000000	.00000000
67.500	.00036002	.00110007	.00055003	.00000000	.00000000	.00000000
90.000	.00036002	.00110007	.00048003	.00000000	.00000000	.00000000
112.500	.00058003	.00116007	.00048003	.00000000	.00000000	.00000000
135.000	.00019001	.00075005	.00062004	.00000000	.00000000	.00000000
157.500	.00051003	.00116007	.00048003	.00000000	.00000000	.00000000
180.000	.00075005	.00158009	.00055003	.00000000	.00000000	.00000000
202.500	.00038002	.00144009	.00068004	.00000000	.00000000	.00000000
225.000	.00035002	.00089005	.00116007	.00000000	.00000000	.00000000
247.500	.00028002	.00103006	.00123007	.00000000	.00000000	.00000000
270.000	.00063004	.00082005	.00110007	.00000000	.00000000	.00000000
292.500	.00023001	.00144009	.00116007	.00000000	.00000000	.00000000
315.000	.00042003	.00096006	.00068004	.00000000	.00000000	.00000000
337.500	.00065004	.00103006	.00089005	.00000000	.00000000	.00000000

- ISCLT INPUT DATA (CONT.) -

- FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY -

SEASON 1

STABILITY CATEGORY 3

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.5000MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00058003	.00178011	.00322019	.00096006	.00000000	.00000000
22.500	.00033002	.00096006	.00171010	.00062004	.00000000	.00000000
45.000	.00024001	.00082005	.00103006	.00027002	.00000000	.00000000
67.500	.00039002	.00075005	.00130009	.00075005	.00000000	.00007000
90.000	.00046003	.00075005	.00329020	.00062004	.00007000	.00007000
112.500	.00019001	.00034002	.00144009	.00027002	.00000000	.00000000
135.000	.00040002	.00089005	.00158009	.00021001	.00000000	.00000000
157.500	.00053003	.00062004	.00213013	.00041002	.00000000	.00000000
180.000	.00145009	.00212013	.00425026	.00192012	.00007000	.00000000
202.500	.00062005	.00116007	.00384023	.00192012	.00000000	.00000000
225.000	.00055003	.00151009	.00384023	.00233014	.00014001	.00007000
247.500	.00040002	.00089005	.00432026	.00144009	.00027002	.00000000
270.000	.00043003	.00116007	.00493030	.00205012	.00000000	.00000000
292.500	.00055003	.00151009	.00349021	.00075005	.00021001	.00007000
315.000	.00043003	.00116007	.00342021	.00096006	.00000000	.00000000
337.500	.00046003	.00068004	.00308019	.00082005	.00000000	.00000000

SEASON 1

STABILITY CATEGORY 4

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.5000MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00068004	.00342021	.01364083	.02031121	.00192012	.00007000
22.500	.00022001	.00301018	.00979059	.01349081	.00158009	.00007000
45.000	.00047003	.00226014	.00719043	.00795048	.00116007	.00007000
67.500	.00104006	.00349021	.01027062	.01329080	.00110007	.00000000
90.000	.00089005	.00630038	.01582095	.01603096	.00123007	.00027002
112.500	.00086005	.00274016	.00815049	.00630038	.00027002	.00007000
135.000	.00056003	.00390023	.01103066	.01110067	.00103006	.00000000
157.500	.00133008	.00500030	.01281077	.01349081	.00130008	.00007000
180.000	.00165010	.00993060	.02507151	.03527212	.00377023	.00034002
202.500	.00061004	.00500030	.01199072	.02014121	.00274016	.00021001
225.000	.00052003	.00322019	.00911055	.01616097	.00274016	.00065004
247.500	.00047003	.00363022	.00733044	.01267076	.00233014	.00027002
270.000	.00082005	.00486029	.01096066	.02856172	.00603036	.00130008
292.500	.00052003	.00459028	.01192072	.03418205	.00521031	.00116007
315.000	.00053003	.00473028	.01137068	.02219133	.00329020	.00034002
337.500	.00073004	.00315019	.01164070	.01507090	.00110007	.00034002

- ISCLT INPUT DATA (CONT.) -

- FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY -

SEASON 1

STABILITY CATEGORY 5

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.5000MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00000000	.00158009	.00575035	.00000000	.00000000	.00000000
22.500	.00000000	.00116007	.00329020	.00000000	.00000000	.00000000
45.000	.00000000	.00116007	.00171010	.00000000	.00000000	.00000000
67.500	.00000000	.00185011	.00240014	.00000000	.00000000	.00000000
90.000	.00000000	.00329020	.00452027	.00000000	.00000000	.00000000
112.500	.00000000	.00192012	.00233014	.00000000	.00000000	.00000000
135.000	.00000000	.00233014	.00363022	.00000000	.00000000	.00000000
157.500	.00000000	.00349021	.00247015	.00000000	.00000000	.00000000
180.000	.00000000	.00973058	.00904054	.00000000	.00000000	.00000000
202.500	.00000000	.00404024	.00575035	.00000000	.00000000	.00000000
225.000	.00000000	.00233014	.00260016	.00000000	.00000000	.00000000
247.500	.00000000	.00199012	.00226014	.00000000	.00000000	.00000000
270.000	.00000000	.00158009	.00849051	.00000000	.00000000	.00000000
292.500	.00000000	.00116007	.00801048	.00000000	.00000000	.00000000
315.000	.00000000	.00178011	.00863052	.00000000	.00000000	.00000000
337.500	.00000000	.00137008	.00493030	.00000000	.00000000	.00000000

SEASON 1

STABILITY CATEGORY 6

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.5000MPS)	WIND SPEED CATEGORY 2 (2.5000MPS)	WIND SPEED CATEGORY 3 (4.3000MPS)	WIND SPEED CATEGORY 4 (6.8000MPS)	WIND SPEED CATEGORY 5 (9.5000MPS)	WIND SPEED CATEGORY 6 (12.5000MPS)
.000	.00216013	.00438026	.00000000	.00000000	.00000000	.00000000
22.500	.00146009	.00240014	.00000000	.00000000	.00000000	.00000000
45.000	.00172010	.00171010	.00000000	.00000000	.00000000	.00000000
67.500	.00285017	.00336020	.00000000	.00000000	.00000000	.00000000
90.000	.00654039	.00562034	.00000000	.00000000	.00000000	.00000000
112.500	.00304018	.00308019	.00000000	.00000000	.00000000	.00000000
135.000	.00348021	.00432026	.00000000	.00000000	.00000000	.00000000
157.500	.00683041	.00842051	.00000000	.00000000	.00000000	.00000000
180.000	.01618097	.02231137	.00000000	.00000000	.00000000	.00000000
202.500	.00660040	.00774046	.00000000	.00000000	.00000000	.00000000
225.000	.00302018	.00562034	.00000000	.00000000	.00000000	.00000000
247.500	.00235014	.00301018	.00000000	.00000000	.00000000	.00000000
270.000	.00334020	.00445027	.00000000	.00000000	.00000000	.00000000
292.500	.00216013	.00404024	.00000000	.00000000	.00000000	.00000000
315.000	.00270016	.00493030	.00000000	.00000000	.00000000	.00000000
337.500	.00242015	.00521031	.00000000	.00000000	.00000000	.00000000

- ISCLT INPUT DATA (CONT.) -

- VERTICAL POTENTIAL TEMPERATURE GRADIENT (DEGREES KELVIN/METER) -

	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
STABILITY CATEGORY 1	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
STABILITY CATEGORY 2	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
STABILITY CATEGORY 3	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
STABILITY CATEGORY 4	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00	.000000E+00
STABILITY CATEGORY 5	.200000E-01	.200000E-01	.200000E-01	.200000E-01	.200000E-01	.200000E-01
STABILITY CATEGORY 6	.350000E-01	.350000E-01	.350000E-01	.350000E-01	.350000E-01	.350000E-01

- WIND PROFILE POWER LAW EXPONENTS -

	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
STABILITY CATEGORY 1	.700000E-01	.700000E-01	.700000E-01	.700000E-01	.700000E-01	.700000E-01
STABILITY CATEGORY 2	.700000E-01	.700000E-01	.700000E-01	.700000E-01	.700000E-01	.700000E-01
STABILITY CATEGORY 3	.100000E+00	.100000E+00	.100000E+00	.100000E+00	.100000E+00	.100000E+00
STABILITY CATEGORY 4	.150000E+00	.150000E+00	.150000E+00	.150000E+00	.150000E+00	.150000E+00
STABILITY CATEGORY 5	.350000E+00	.350000E+00	.350000E+00	.350000E+00	.350000E+00	.350000E+00
STABILITY CATEGORY 6	.550000E+00	.550000E+00	.550000E+00	.550000E+00	.550000E+00	.550000E+00

```
                                   - SOURCE INPUT DATA -

C T SOURCE SOURCE     X           Y       EMISSION  BASE /
A A NUMBER  TYPE  COORDINATE  COORDINATE   HEIGHT  ELEV- /              - SOURCE DETAILS DEPENDING ON TYPE -
R P                  (M)         (M)         (M)   ATION /
D E                                                 (M)  /
----------------------------------------------------------------------------------------------------------------------
X       1  AREA         -.55     -330.35     .10      .00 WIDTH OF AREA (M)=  381.10
                                                          - SOURCE STRENGTHS ( GRAMS PER SEC  PER SQUARE METER      ) -
                                                                SEASON 1     SEASON 2     SEASON 3     SEASON 4
                                                               1.00000E-06
```

** ANNUAL GROUND LEVEL CONCENTRATION (MICROGRAMS PER CUBIC METER) DUE TO SOURCE : **

- GRID SYSTEM RECEPTORS -
- X AXIS (DISTANCE, METERS) -
- CONCENTRATION -

Y AXIS (DISTANCE, METERS)	-410.000	-310.000	-210.000	-110.000	-10.000	90.000	190.000	290.000	390.000
410.000	.256677	.321045	.390453	.476019	.581373	.659745	.716951	[illegible]	[illegible]
310.000	.267137	.367341	.460735	.591157	.724323	.909457	.903621	.515156	[illegible]
210.000	.271255	.395822	.542513	.715705	.929351	1.097446	1.172537	1.094109	[illegible]
110.000	.301711	.474281	.625742	.915796	1.221653	1.465983	1.625762	1.470861	[illegible]
10.000	.325535	.459867	.718380	1.099972	1.578497	1.939857	2.202631	2.015075	[illegible]
-90.000	.340041	.448072	.771574	1.192412	1.848222	.000000	.000000	.000000	[illegible]
-190.000	.339815	.466272	.802702	1.396009	2.112393	.000000	.000000	.000000	[illegible]
-290.000	.315472	.402283	.615217	.912466	1.194483	.000000	.000000	.000000	[illegible]
-390.000	.278678	.363907	.495154	.705673	.951574	1.204835	1.420099	1.254987	[illegible]
-490.000	.245385	.302784	.384050	.527544	.705631	.891346	.980417	.909457	1.043052
-590.000	.200996	.246990	.303110	.375527	.482174	.586430	.638565	.620575	.787732
-690.000	.173930	.207227	.234271	.279918	.330211	.364121	.419073	.406594	.558402
-790.000	.147971	.162221	.176205	.212042	.239175	.275690	.298072	.305149	.304235

- GRID SYSTEM RECEPTORS -
- X AXIS (DISTANCE, METERS) -
- CONCENTRATION -

Y AXIS (DISTANCE, METERS)	490.000	590.000	690.000	790.000
410.000	.506334	.400853	.329308	.263107
310.000	.598967	.468075	.373068	.270500
210.000	.725095	.548195	.398856	.271990
110.000	.931442	.636500	.440930	.304761
10.000	1.157991	.753730	.475906	.329938
-90.000	1.309051	.807966	.481208	.357555
-190.000	1.136600	.767721	.516434	.366311
-290.000	1.063078	.715938	.471641	.361153
-390.000	.828501	.604266	.446255	.339445
-490.000	.641720	.491278	.389967	.314922
-590.000	.477540	.409584	.335337	.275573
-690.000	.356345	.326660	.296773	.249896
-790.000	.258237	.237739	.241796	.224458

```
****************************************** END OF ISCLT PROGRAM,     1 SOURCES PROCESSED ******************************************
top - Program terminated.
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P

APPENDIX P

MODELING OF LANDFILL GAS GENERATION

Appendix P

Modeling of Landfill Gas Generation

In order to determine potential future risks caused by exposure to landfill gas, it is necessary to estimate rates of gas generation in the the future. The Palos Verdes Kinetic Model as presented in Methane Generation and Recovery From Landfills, Emcon Associates, 1982, was used to roughly estimate future gas generation.

The rate of gas production at any time is a function of refuse composition, moisture content, age of the refuse, temperature, nutrient content, pH and alkalinity. Given the dearth of historical information concerning the filling of the Woodstock Landfill, the following assumptions were required.

Refuse composition is mostly municipal waste, with unknown quantities of industrial sludge and lime slurry added during periods of the Site operation. Since high concentrations of calcium, magnesium, and toxic materials inhibit gas production, a conservative estimation, maximizing potential generation rates, would include only municipal waste. Percent composition of the various components of municipal waste were estimated for food waste, garden waste, paper, rubber and plastics, textiles, wood, and inert rubble, and are presented in the calculations at the end of this appendix. This information provides estimates of nutrient content, pH, and alkalinity.

The amount of compaction also effects the rate of gas production by increasing available surface area and contact between organisms and waste. For Woodstock, a moderate density of 1000 lbs/cubic yard is assumed.

Moisture content has been estimated at 30%. While high moisture content in the range of 60-80% favors methane gas production, moisture ranges of refuse at the time of placement average about 25%.

The rate of placement will have a significant effect on model predictions. Filling at Woodstock began in 1935 and continued until 1975. However, open burning was practiced until about 1958. Since no information is available on rates of filling or total actual wasted placed in the landfill, the total waste volume estimate of 13 million cubic feet (484,000 cubic yards) presented in Table 4-2 was used to estimate annual rates of filling. It was estimated that 10% of this volume was placed between 1935 and 1958 when open burning occurred, with the remaining 90% placed between 1959 and 1975. This conservatively estimates the majority of waste placement occurred in the latter stage of the Landfill's operation.

Based on the these assumptions, modelled results for landfill gas generation at the Woodstock Landfill indicate gas generation peaked approximately 10 years ago (in 1980) at approximately 140 cubic feet per minute (CFM), and has declined to approximately 32 CFM in 1991, with a further drop to 15 CFM by 1995.

JAH/ndj/MWK/DWH
[mad-602-22d]
60776.29

WOODSTOCK LANDFILL RI/FS 10/10/91

TOTAL ESTIMATED REFUSE FILLING RATE

Year	Refuse Volume (CY)	Density (LBS/CY)	Total Tons
1935	2,093	1000	1,047
1936	2,093	1000	1,047
1937	2,093	1000	1,047
1938	2,093	1000	1,047
1939	2,093	1000	1,047
1940	2,093	1000	1,047
1941	2,093	1000	1,047
1942	2,093	1000	1,047
1943	2,093	1000	1,047
1944	2,093	1000	1,047
1945	2,093	1000	1,047
1946	2,093	1000	1,047
1947	2,093	1000	1,047
1948	2,093	1000	1,047
1949	2,093	1000	1,047
1950	2,093	1000	1,047
1951	2,093	1000	1,047
1952	2,093	1000	1,047
1953	2,093	1000	1,047
1954	2,093	1000	1,047
1955	2,093	1000	1,047
1956	2,093	1000	1,047
1957	2,093	1000	1,047
1958	2,093	1000	1,047
1959	25,490	1000	12,745
1960	25,490	1000	12,745
1961	25,490	1000	12,745
1962	25,490	1000	12,745
1963	25,490	1000	12,745
1964	25,490	1000	12,745
1965	25,490	1000	12,745
1966	25,490	1000	12,745
1967	25,490	1000	12,745
1968	25,490	1000	12,745
1969	25,490	1000	12,745
1970	25,490	1000	12,745
1971	25,490	1000	12,745
1972	25,490	1000	12,745
1973	25,490	1000	12,745
1974	25,490	1000	12,745
1975	25,490	1000	12,745
TOTALS	483,575		241,787

WOODSTOCK LANDFILL RI/FS
ESTIMATED REFUSE CHARACTERIZATION

10/10/91

Component(1)	Composite	Waste Type (%)		t@	t#
Food Waste	9.0	0	0	1.5	3.5
Garden Waste	10.0	0	0	7	30
Paper Products	42.0	0	0	10	30
Plastic/Rubber	12.0	0	0	20	60
Textiles	2.0	0	0	7	20
Wood	6.0	0	0	15	50
Rubble/Inerts	19.0	0	0	0	0
Moisture Content	30%	0%	0%		
Dry Solids	70%	0%	0%		
Volatile Solids (Dry Wt. Basis)	56%	0%	0%		
Volatile Solids (Biodegradable) (Dry Wt. Basis)	47%	0%	0%		

Maximum Methane Production (3)				Total Methane Production
(cu.ft./lbm)	1.54	0.00	0.00	1.54 (cu.ft./lbm)

(1) Refuse characterization based on "Methane Generation and Recovery From Landfills", Emcon Associates, and Warzyn Inc.

(2) Maximum methane production based on the biodegradability of volatile solids present in the refuse as described in "Methane Generation and Recovery From Landfills", Emcon Associates.

Methane Generation Calculation (3)

First Stage Equation:

$$G = (L/2)e^{-k1(t@ - t)}$$

Second Stage Equation:

$$G = L[1 - .5e^{-k2(t - t@)}]$$

Where:

G = Volume of gas produced prior to time t

L = Maximum methane production

k1 = ln(50/t@)

k2 = ln(50)/(t# - t@)

t@ = time when 50% of methane has been produced in years

t# = time when 99% of methane has been produced in years

(3) Based on the Palos Verdes Kinetic Model where the first stage methane production rate is proportional to the volume of methane already produced until half of the potential methane has been generated. The second stage methane production rate is proportional to the volume of methane remaining to be produced.

10/10/91

WOODSTOCK LANDFILL RI/FS
ESTIMATED LANDFILL GAS GENERATION RATE

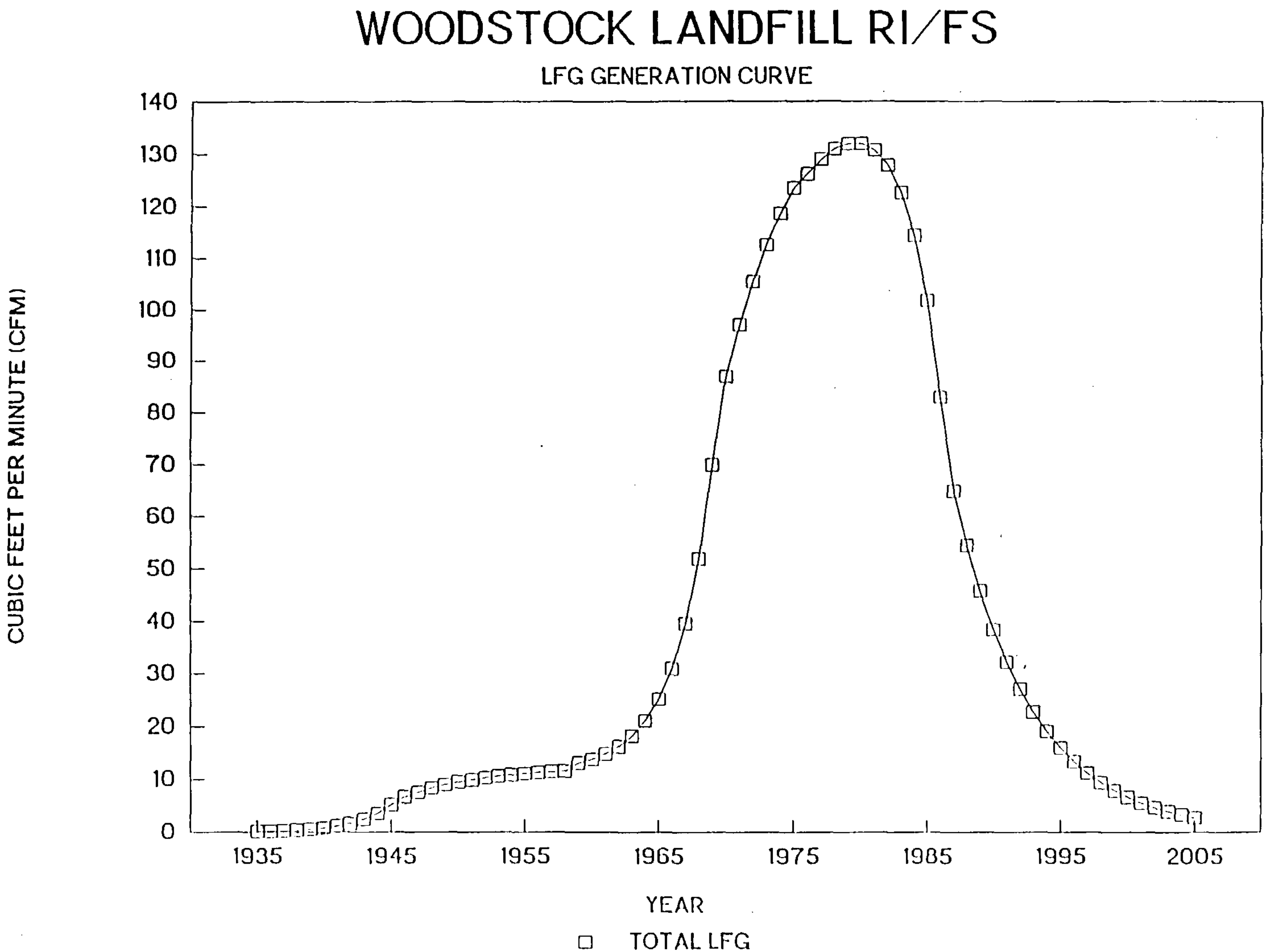
Year	Total LFG (CFM)
1935	0
1936	0
1937	0
1938	0
1939	1
1940	1
1941	1
1942	2
1943	2
1944	4
1945	5
1946	7
1947	8
1948	8
1949	9
1950	10
1951	10
1952	10
1953	11
1954	11
1955	11
1956	11
1957	11
1958	12
1959	13
1960	14
1961	15
1962	16
1963	18
1964	21
1965	25
1966	31
1967	39
1968	52
1969	70
1970	87
1971	97
1972	105
1973	113
1974	118
1975	123
1976	126
1977	129
1978	131
1979	132
1980	132
1981	131
1982	128
1983	123

10/10/91

WOODSTOCK LANDFILL RI/FS
ESTIMATED LANDFILL GAS GENERATION RATE

Year	Total LFG (CFM)
1984	114
1985	102
1986	83
1987	65
1988	54
1989	46
1990	38
1991	32
1992	27
1993	23
1994	19
1995	16
1996	13
1997	11
1998	9
1999	8
2000	7
2001	6
2002	5
2003	4
2004	3
2005	3

BM/bm/JAH


WOODSTOCK LANDFILL RI/FS
LFG GENERATION CURVE
CUBIC FEET PER MINUTE (CFM)
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1935
1945
1955
1965
1975
1985
1995
2005
YEAR
TOTAL LFG

Q

APPENDIX Q

INDOOR AIR MODELING OF VOC CONCENTRATIONS DUE TO THE INTRUSION OF LANDFILL GAS

APPENDIX Q

INDOOR AIR MODELING OF VOC CONCENTRATIONS DUE TO THE INTRUSION OF LANDFILL GAS

An analysis was conducted to quantify potential indoor air concentrations of volatile organic compounds (VOCs) due to landfill gas intrusion into future residences built on the Woodstock Landfill. This analysis consisted of a review of available literature concerning soil gas intrusion into homes and the estimation of potential VOC air concentrations in a hypothetical house.

Soil Gas Intrusion

Soil gas may enter a house through cracks and pores in foundations or basement walls and through gaps around building joints or plumbing. The flow of soil gas into a house may be driven by diffusion or by advection, movement due to temperature and pressure differences between the inside and outdoor air. Temperature differences create a "stack" effect: As the air in the house is heated, the air rises and leaves the house through cracks, holes, and openings. Cold air from outside the house is drawn into the house through openings in the walls, floor, or basement. Pressure differences between the inside and outside air are created by wind blowing against the walls of the house or by ventilation systems that do not have balanced intake and exhaust rates (Wadden and Scheff, 1983). The advective flow created by these temperature and pressure differences is the principal means by which soil gas enters a house. (Garbesi and Sextro, 1990).

Advective flow may be particularly important in houses with basements because of the large interface with the soil and large negative pressures that are possible when the house is heated during winter. Basement pressures have been measured under normal operating conditions during the winter between -2 and -6 Pascals (Pa) (Garbesi and Sextro, 1990). The actual pressure gradient and flow created by such conditions is very difficult to predict and currently not well understood. Flows may vary over several orders of magnitude depending on the permeability of the soil, the effective permeability of the basement substructure, and the extent and magnitude of the pressure gradient (Garbesi and Sextro, 1989; Garbesi, 1991).

Turk, et. al. (1990) measured actual rates of soil gas entry into 15 houses in the Pacific Northwest. In the houses studied, soil gas entry rates constituted between 1% and 21% of the house ventilation rates. The mean of the observed values was 5.3%. Thus, on the average, the air in the houses studied consisted of 5% soil gas and 95% outdoor air.

Estimation of Indoor Concentrations

The potential indoor concentrations of VOCs due to landfill gas intrusion were estimated for a hypothetical house and basement shown in Figure Q-1. The volume of the living space, V_L, was assumed to be 396 m^3, based on a 4-person house with an average space of 99 m^3/person (Nazaroff, et. al. 1988). The volume of the basement, V_b, was assumed to be equal to the volume of the living space. The range for house ventilation rates during winter extends from 0.1 to 1 air changes per hour (Nero, 1988). Therefore, the house was assumed to be ventilated at a worst-case rate of 0.1 air changes per hour or 39.6 m^3/h. The basement was assumed to be ventilated at 0.05 air changes per hour or 19.8 m^3/h.

Landfill gas was assumed to enter the basement of the house via advective flow through cracks and pores in the basement walls and via diffusion through a crack between the basement walls and the basement floor, conservatively assumed to be 1 cm wide.

Given the difficulty of predicting the advective flow into the basement, the soil gas entry rate, Q_s, was estimated from the assumed ventilation rate for the house and the percentage of ventilation rate represented by soil gas entry observed by Turk et. al. (1990). Using the mean value of 5.3%, Q_s was estimated to be 2.1 m^3/h.

The rate of soil gas diffusion, S, was calculated using a linearized version of Fick's law for steady-state diffusion along a concentration gradient and the Millington-Quirk expression for an effective diffusion coefficient of gas through a partially saturated soil (Dougherty, 1991). This calculation is as follows:

$$S = \frac{D_e * A * C_s}{X}$$

Where S = soil gas entry rate, [ug/h]

D_e = effective diffusivity of gas in soil, (m^2/h)

$$D_e = \frac{D_a * P_a^{3.33}}{P_t^2} * 0.36$$

where D_a = diffusivity of gas in air, estimated to be 1 cm^2/s (Finlayson-Pitts and Pitts, 1986)

P_t = total soil porosity
= $1 - (d_b/d_p)$

P_a = air filled porosity
= $P_t - (m * d_b)$

where d_b = 1.8 g/cm^3, the average bulk density of the soil determined from two borings at the site (LW01 and LW02)

d_p = 2.6 g/cm^3, the particle density of the soil determined from two borings at the site (LW01 and LW02)

m = 14%, moisture content of the soil determined from two borings at the site (LW01 and LW02)

A = 0.5 m^2, surface area over which diffusion occurs Calculated assuming that the basement volume is 396 m^3, the basement depth is 3 m, the basement floor is a square, and the crack between the basement floor and walls is 1 cm wide.

C_s = concentration of chemical in soil gas [ug/m^3]

X = 1 m, assumed distance from the basement floor to the source of the soil gas

0.36 = unit conversion factor from cm^2/s to m^2/h

Based on these relationships, the rate of diffusion, S, is equal to 1.6×10^{-4} C_s (ug/h).

Based on conservation of mass, the rate of change in concentrations in the basement and living areas are given by the following equations:

$$\frac{dC_L}{dt} = \frac{Q_oC_o+Q_bC_b-Q_LC_L-Q_eC_L}{V_L} \quad \text{and} \quad \frac{dC_b}{dt} = \frac{Q_sC_s+Q_LC_L+S-Q_bC_b}{V_b}$$

Where C_s = concentration in soil gas (mg/m^3)

C_b = concentration in basement (mg/m^3)

C_L = concentration in living space (mg/m^3)

C_o = concentration in outdoor air, assumed to be zero

V_b = volume of basement, 396 m^3

V_L = volume of living space, 396 m^3

Q_s = volumetric flow from soil to basement, 2.1 m^3/h (5.3% of total ventilation)

Q_b = volumetric flow from basement to living space, 19.8 m^3/h (0.05 air changes/hour)

Q_L = volumetric flow from living space to basement, = $Q_b - Q_s$

Q_e = volumetric flow from living space to outside air, 39.6 m^3/h (0.1 air changes/hour)

Q_o = volumetric flow from outside to living space, = $Q_e + Q_L - Q_b$

After some time, the concentrations in the rooms will reach a steady state and the rates of change will be zero. Under these conditions:

$$C_L = \frac{Q_sC_s + S}{Q_e} \quad \text{and} \quad C_b = \frac{Q_sC_s + S}{Q_b} * \frac{Q_e + Q_L}{Q_e}$$

Given the maximum soil gas concentrations of VOCs observed at the Woodstock Landfill, C_L and C_b were calculated using these relationships. The results of these calculations are given in Table Q-1. These estimated concentrations are based on winter heating conditions which maximize the rate of landfill gas intrusion and minimize ventilation of the living space. However, the uncertainty in these estimates is very large and actual winter-time concentrations could be lower or higher, ranging over several orders of magnitude. At other times of the year, natural ventilation would be greater and advective flow would be lower due to a lower temperature differential, resulting in lower concentrations. Therefore, the estimated winter-time concentrations may be taken as worst-case annual average indoor concentrations.

References

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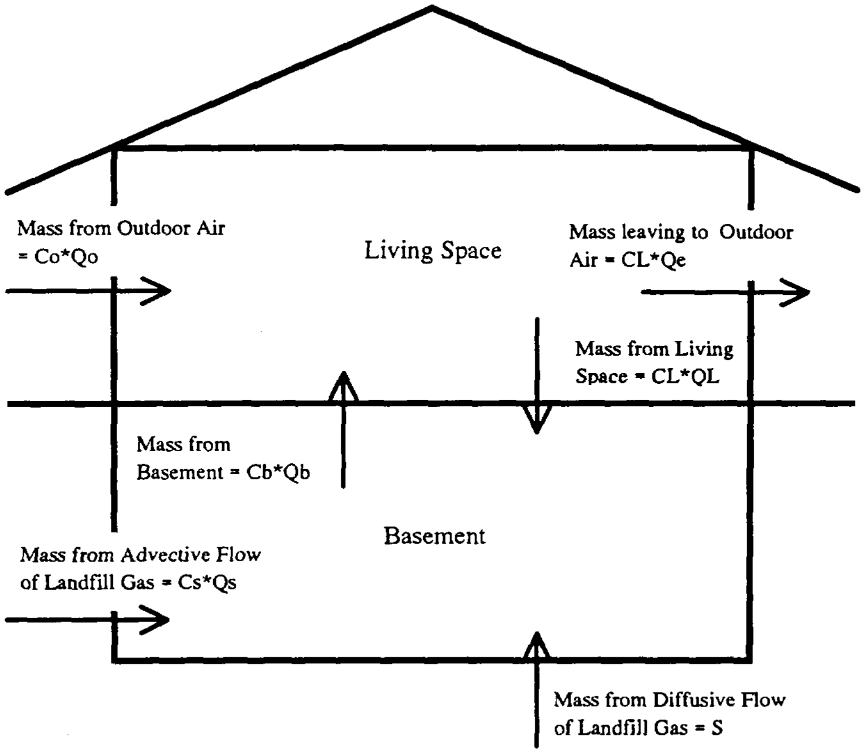

Figure Q-1. Landfill gas intrusion and ventilation in a hypothetical house with a basement. Note that the variables are defined in the text of Appendix Q.

TABLE Q-1

Estimated Volatile Organic Compound (VOC) Indoor Air Concentrations

Compound	Max Soil[1] Gas Conc (ppbv)	Mol Wt[2]	Max Soil[3] Gas Conc (ug/m3)	Soil Emission[4] Rate from Diffusion (ug/h)	Conc[5] Living Area (ug/m3)	Conc[6] Basement (ug/m3)	Avg[7] Conc (ug/m3)
Freon 114	78	171	555	0.09	29	85	57
Chloroethane	470	65	1261	0.20	67	194	130
Benzene	220	78	715	0.11	38	110	74
Toluene	130	92	498	0.08	26	76	51
Chlorobenzene	120	113	562	0.09	30	86	58
Ethylbenzene	310	106	1369	0.22	73	210	141
Xylenes	440	106	1943	0.31	103	298	201
4-Ethyltoluene	160	120	800	0.13	42	123	83
1,3,5-Trimethylbenzene	70	120	350	0.06	19	54	36
1,2,4-Trimethylbenzene	320	120	1600	0.26	85	246	165

Footnotes:

1. Maximum soil gas concentration of VOC (parts per billion, volume to volume). See Table 8-2.
2. Molecular weight (g/mole) of VOC.
3. Maximum soil gas concentrations (ug/m^3) = ppbv * mol wt/24.5.
4. See text for calculation of soil gas diffusion rate into basement.
5. Conc. Living Area = Concentrations of VOCs in living area of hypothetical home (ie., upstairs).
6. Conc. Basement = Concentrations of VOCs in basement of hypothetical home.
7. Avg. Conc = Average of concentration in living area and concentration in basement.

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R

APPENDIX R

SCREENING METHOD FOR ESTIMATING INHALATION EXPOSURE TO VOLATILE CHEMICALS FROM DOMESTIC WATER

Shower Inhalation Intake Calculation

A screening method for estimating the indoor air concentrations from indoor water uses and the resulting human inhalation exposures, with an emphasis on showering, has been developed by the Office of Health and Environmental Assessment- Exposure Assessment Group, based on procedures developed by Julian Andelman at the University of Pittsburgh. The screening method, which presents in detail the methods used to estimate chemical exposure from showering, is included in this appendix. In the baseline risk assessment, the shower exposure equation is used in conjunction with the daily intake equation for inhalation of chemicals to calculate the average daily chemical intake associated with showering and grooming. This introduction summarizes how the two equations are incorporated.

Showering exposes a person to chemicals present in groundwater used for showering, through both dermal and inhalation exposure routes. The portion of the chemical in the water (Cw) that will volatilize is estimated to determine the chemical concentration in air (CA). The time spent in the shower, as well as time spent in the bathroom after the shower, are estimated and summed to determine the exposure time (ET). The breathing or inhalation rate (IR) is also estimated. These factors (i.e., CA, IR and ET) are incorporated into both the shower exposure equation, presented below, and the daily intake equation presented in table L-39 of Appendix L. The factors that average the daily exposure over the lifetime of an average receptor are included in the daily intake equation only. By integrating the two equations, the average daily chemical intake from the showering pathway was calculated.

The shower exposure equation estimates a persons chemical exposure in terms of mg of chemical per shower event, or mg/day:

$$Ei = \frac{\left(\frac{Cw * f * Fw * t_1}{2}\right)}{Va} * (B * t_1) + \frac{\left(\frac{Cw * f * Fw * t_1}{2}\right)}{Va} * (B * t_2)$$

where

- Ei = Magnitude of chemical air exposure (mg/day)
- Cw = Concentration of chemical in water (mg/L)
- f = Fraction volatilized from water to air (assume 90%-Volatiles, 50%-Semivolatiles, 0%-Metals)
- Fw = Flow rate of water from shower (600 L/hr)
- t_1 = Shower time period (0.08 hr/day)
- t_2 = Bathroom time period (i.e., after showering while grooming) (0.20 hr/day)
- Va = Bathroom volume (10,000 L)
- B = Persons inhalation rate (833 L/hr)

The shower exposure equation, with the inputs given above, can be reduced to the following:

$$Ei\ (mg/day) = Cw * f * 0.959616$$

The daily intake equation for inhalation of chemicals from air, presented in Table L-39, is as follows:

$$I = \frac{CA * IR * ET * EF * ED}{BW * AT}$$

where

I	=	Chemical intake due to inhalation exposure (mg/kg-day)
CA	=	Contaminant concentration in air (mg/m^3)
IR	=	Inhalation rate (L/hr which can be converted to m^3/day)
ET	=	Exposure time (hours/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)
BW	=	Body weight (kg)
AT	=	Averaging time (days)

As described previously, the shower exposure equation includes factors for exposure time (ET) and inhalation rate (IR). The chemical exposure per shower, calculated from the shower exposure equation, can be integrated into the daily intake equation to provide the average chemical exposure over the lifetime of the receptor associated with showering and grooming. By including the constant derived by reducing the shower exposure equation, the factors common to both equations are:

$$Cw * f * 0.959616 = CA * IR * ET$$

The shower scenario is thus integrated into the inhalation intake equation by substituting the one set of factors (Cw * f * 0.959616) for the other set of factors (CA * IR * ET), which results in the following equation:

$$I = \frac{CA * f * 0.959616 * EF * ED}{BW * AT}$$

This equation was used to calculate the daily intakes associated with showering and grooming in the baseline risk assessment.

It should be noted, that when calculating the daily intake for dermal chemical exposure resulting from showering (i.e., refer to table L-29 and L-41 in Appendix L), the concentration in water was decreased due to volatilization. The chemical concentration in water was scaled downward by the fraction not volatilized: 0.10 for volatiles, 0.50 for semivolatiles, and 1.00 for metals when calculating dermal intakes during showering.

References:

Andelman, J.B. 1985. Human Exposures to Volatile Haloganated Organic Chemicals in Indoor and Outdoor Air. Environmental Health Perspective 62: 313-318.

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SCREENING METHOD FOR ESTIMATING INHALATION EXPOSURE TO VOLATILE CHEMICALS FROM DOMESTIC WATER

1. Introduction

The following discussion has been developed to provide a screening method for estimating the indoor air concentrations of volatile chemicals from indoor water uses and the resulting human inhalation exposures, with an emphasis on showers. A computerized model titled MAVRIQ (Model for Analysis of Volatiles and Residential Indoor-Air Quality), which is under development, may also be used to refine the exposure estimates since it more accurately accounts for human behavioral and water use patterns.

This procedure evolved from research done by Julian Andelman at the Universtity of Pittsburg under funding from the Expsoure Assessment Group at US EPA in Washington, DC. The references given provide a more detailed description of these procedures and related work.

2. When is Inhalation Exposure of Concern?

In order to determine the significance of the inhalation pathway the ratio of the vapor inhalation exposure to the water ingestion exposure can be calculated. Using Henry's Law Constant to obtain the equilibrium concentration in air, and setting a ratio of < 0.1 as criteria, the equation can be derived as follow:

$$\frac{\text{max inhalation exposure}}{\text{water ingestion exposure}} < 0.1 \qquad (1)$$

$$\frac{H\,C_w \times (20.000\ \text{L/day})}{C_w \times (2\ \text{L/day})} < 0.1 \qquad (2)$$

$$H < 10^{-5} \qquad (3)$$

Where C_w = contaminant concentration in water (mg/L)
H = Henry's Law Constant (unitless)

The unitless Henry's Law Constant can be calculated by using the following equation.

$$H = H'/RT$$

where H' = Henry's Law Constant in atm-m^3/mol
R = gas constant in atm-m^3/mol °K
T = temperature in °K.

Assuming a typical water temperature in a shower scenario of 40°C, RT is 2.6×10^{-2} atm-m^3/mol.
Equation (3) suggests that for compounds with Henry's Law Constants of < 10^{-5}, the inhalation exposure would not exceed ingestion and is probably much less, therefore the inhalation pathway may not be of concern when compared to ingestion. Caution should be used when applying this criterion. If the ingestion exposure is significant, the inhalation exposure, although orders of magnitude less, may also be significant when considered separately.

3. Showering Exposure

The derivations and assumptions of the equations used to estimate exposure through the showering scenario are included in Appendix 1.

The exposure equation below accounts for the exposure during the showering time and the exposure during the period subsequent to the shower where there is a decay of the chemical concentration.

$$E_i = [C_{aAVG1}Bt_1]_{shower} + [C_{aAVG2}Bt_2]_{after\ shower} \quad (4)$$

Where: E_i = exposure [mg]
C_{aAVG1} = average air concentration during shower [mg/L]
C_{aAVG2} = average air concentration after shower [mg/L]
B = breathing rate [L/hr]
t_1 = shower period [hr]
t_2 = after shower period [hr]

C_{aAVG1} and C_{aAVG2} are estimated using equations (5) and (6) and (7) below.

$$C_{aAVG1} = C_{aMAX}/2 \quad (5)$$

$$C_{aAVG2} = C_{aMAX} \quad (6)$$

$$C_{aMAX} = \frac{C_w \times f \times F_w \times t_1}{V_a} \quad (7)$$

Where: C_{aMAX} = maximum air concentration in bathroom [mg/L]
C_w = water concentration [mg/L]
f = fraction volatilization [unitless]
F_w = water flow rate [L/hr]
V_a = bathroom size [L]

Default values for the variables in these equations are tabulated in table 1.

Using equations (4) through (7) and the average or most probable values from Table 1, one can estimate the exposure during showering.

Example:
<u>**Assumptions**</u>

$f = .75$
$F_w = 600\ L/hr$
$t_1 = 0.08\ hr$
$t_2 = 0.2\ hr$
$V_a = 10{,}000\ L$

$$C_{aMAX} = \frac{C_w\,(0.75)(600L/hr)(0.08\ hr)}{(10{,}000\ L)}$$

$$= 3.6 \times 10^{-3}\ C_w$$

$$C_{aAVG} = 1.8 \times 10^{-3}\ C_w$$

$$E_I = 1.8 \times 10^{-3}\ C_w(833L/hr)(0.08hr) + 3.6 \times 10^{-3}\ C_w(833L/hr)(0.2hr)$$

$$= 0.72(L)\ C_w$$

TABLE 1

Variable	Value or Range	Reference
Fraction Volatilization (f)	0.5 - 0.9 (typical=0.75)	1
Water Flow Rate (F_w) [L/hr]	600 - 1,800 (mean=600)	2
Shower Period (t_1) [hr]	0.08 - 0.3 (mean=0.08)	2
After Shower Period (t_2)	0.2 (typical)	1
Bathroom size (V_b) [L]	8,300 - 9,800	3
Breathing Rate (B) [L/hr]	833 (20m^3/day)	4

1. Andelman, J., Total Exposure to Volatile Organic Compounds in Potable Water, Chapter 20, Significance and Treatment of Volatile Organic Compounds in Water Supplies

2. U.S. Department of Housing and Urban Development, Residential Water Conservation Projects, March 1984, Contract H-5230

3. Giardino NJ, Gumerman E, Andelman JB, Wilkes CR, Small MJ, Borrazo JE, Davidson CI (1990), Real-Time Air Measurements of Trichluroethylene in Domestic Bathrooms using Contaminated Water

4. U.S. EPA Factors Handbook

4. Whole House Exposure

Similarly, a one-compartment indoor-air model may be used to describe the range of average indoor-air concentrations that are likely to be encountered from a volatile organic chemical. The equation does not address the time and space variations that will be encountered throughout the day in the home. The exposure estimates obtained using the air concentrations from equation (8) do not include those that would occur at the point of water use, such as during showering.

The air concentration can be estimated by using the equation below.

$$C_a = \frac{WHF\ C_w\ f}{HV\ ER\ MC} \qquad (8)$$

where; C_a = concentration in air (mg/m^3)
C_w = concentration in water (mg/L)
WFH = water flow rate in whole house (L/day)
HV = house volume (m^3)
ER = exchange rate (air changes/day)
MC = mixing coefficient (unitless)
f = fraction of contaminant that volatilizes (unitless)

Table 2 shows a list of the ranges of values that these variables can take. An example of the use of equation (8) is presented below.

Assumptions

WFH = 723 (L/day)
HV = 177.7 (m^3)
ER = 13.7 - 58.8 (air changes/day)
MC = 0.15 - 1.0 (unitless)
f = 0.5 - 1.0 (unitless)

$$C_a = (0.03 - 2.0\ [L/m^3])\ C_w\ [mg/L] \qquad (9)$$

TABLE 2

Variable	Value or Range	Reference
Water Flow Rate (WFH) [L/day]	723 (typical)	1
House Volume (HV) [m^3]	177.7 (typical?)	2
Exchange Rate (ER) [air changes/day]	13.7 - 58.8	3
Exchange Rate (ER) [air changes/day]	21.6 - 84.0	4
Mixing Coefficient (MC) (unitless)	0.15 - 1.0	5
Fraction Volatilization (f) [unitless]	0.5 - 1.0	6

1. U.S. Department of Housing and Urban Development (1984) Residential Water Conservation Projects

2. Axley J (1988) Progress Toward a General Analytical Method for Predicting Indoor Air Pollution in Buildings: Indoor Air Quality Modeling Phase III Report. NBSIR 88-3814

3. Grimsrud D.T., Sherman M.H., and Sonderegger R.C. (1982) Calculating infiltration: Implications for a Construction Quality Standard. Proceedings - ASHRAE/DEO Conference on Thermal Performance of the Exterior Envelopes of Buildings, Las Vegas, NV, Lawrence Berkeley Laboratory Report, LBL-9416. (refers to new houses)

4. ASHRAE (1985) Natural Ventilation and Infiltration. ASHRAE Fundamentals Handbook, Chapter 22, ASHRAE Inc., Atlanta, GA. (refers to older houses)

5. U.S. EPA (1987); Exposure to Volatilized Drinking Water Contaminants Via Inhalation - Importance Relative to Ingestion; Office of Drinking Water, Criteria and Standards Division, Health Effects Branch.

6. Cantor, K.P., Christman R.F., Ram, N.M., Significance and Treatment of Volatile Organic

Compounds in Water Supplies; Chapter 20 - Total Exposure to Volatile Organic Compounds in Potable Water; Julian B. Andelman

Note: The ranges represent the average value and the maximum value. For the range presented in reference #4, the first value represents the median. Values presented for mixing coefficients are based on judgment.

APPENDIX O

NONCANCER AND CANCER HUMAN HEALTH RISK ESTIMATES

Table O-1

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: Trespassers
Land Use: Current Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS		CANCER RISKS	
		Inhalation	% of Total	Inhalation	% of Total
VOLATILES					
Chloroethane		7.1e-07	0.2	ND	0
Benzene		ND	0.0	4.8e-09	100
Toluene		4.0e-07	0.1	ND	0
Chlorobenzene		1.8e-04	47.7	ND	0
Ethylbenzene		7.8e-06	2.0	ND	0
Xylenes (mixed)		1.0e-05	2.7	ND	0
Freon		1.8e-04	46.7	ND	0
4-Ethyl Toluene		6.5e-07	0.2	ND	0
1,3,5-Trimethylbenzene		2.8e-07	0.1	ND	0
1,2,4-Trimethylbenzene		1.3e-06	0.3	ND	0
	Totals	3.8e-04	100.0%	4.8e-09	100.0%

(a) Toxicity values not available for Freon-114, dichlorodifluoroethane used.
(b) Toxicity values for ethyl toluene not available, toluene used instead.
(c) Toxicity values for trimethylbenzene not available, toluene used instead.

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

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APPENDIX O
Health Risk Estimate Table Index

Land Use	Receptor	Pathway	Health Risk Estimates
Current	Trespasser	Ambient Air	O-1
"	"	Surface Soil	O-2
"	"	Creek Surface Water	O-3
"	"	Wetland Surface Water	O-4
"	"	Creek Sediment	O-5
"	"	Wetland Sediment	O-6
"	Off-Site Resident	Ambient Air	O-7
ıture	Park User	Ambient Air	O-8
"	"	Surface Soil	O-9
"	"	Creek Surface Water	O-10
"	"	Wetland Surface Water	O-11
"	"	Creek Sediment	O-12
"	"	Wetland Sediment	O-13
"	On-Site Resident	Ambient Air	O-14
"	"	Surface Soil	O-15
"	"	Vegetables	O-16
"	"	Groundwater (Leachate)	O-17
"	"	Creek Surface Water	O-18
"	"	Wetland Surface Water	O-19
"	"	Creek Sediment	O-20
"	"	Wetland Sediment	O-21
"	"	Indoor Air	O-22
"	Off-Site Resident	Ambient Air	O-23
"	"	Groundwater (Aquifer)	O-24
"	"	Creek Surface Water	O-25
"	"	Creek Sediment	O-26

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Table O-2

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Soil
Source Area: Landfill

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS				CANCER RISKS			
		Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
SEMIVOLATILES									
4-Chloroaniline		6.2e-04	4.3e-05	6.6e-04	0.6	ND	ND	0.0e+00	0.0
Dimethylphthalate		1.2e-06	8.6e-08	1.3e-06	0.0	ND	ND	0.0e+00	0.0
Phenanthrene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Di-n-butylphthalate		1.7e-05	2.1e-06	1.9e-05	0.0	ND	ND	0.0e+00	0.0
Fluoranthene		6.8e-05	4.7e-06	7.3e-05	0.1	ND	ND	0.0e+00	0.0
Pyrene		1.1e-04	7.5e-06	1.2e-04	0.1	ND	ND	0.0e+00	0.0
Butylbenzylphthalate		1.0e-05	1.3e-06	1.1e-05	0.0	ND	ND	0.0e+00	0.0
Benzo(a)anthracene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Chrysene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(b)fluoranthene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(k)fluoranthene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(a)pyrene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Ideno(1,2,3-cd)pyrene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Dibenz(a,h)anthracene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(g,h,i)perylene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Total Carcinogenic PAHs		ND	ND	0.0e+00	0.0	4.2e-05	2.9e-06	4.5e-05	96.9
METALS									
Barium		2.4e-02	5.1e-03	2.9e-02	27.8	ND	ND	0.0e+00	0.0
Cadmium (food/soil)		6.8e-03	2.0e-03	8.8e-03	8.3	ND	ND	0.0e+00	0.0
Chromium VI		6.2e-03	1.3e-02	1.9e-02	18.1	ND	ND	0.0e+00	0.0
Copper		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Mercury		1.0e-02	6.3e-03	1.6e-02	15.5	ND	ND	0.0e+00	0.0
Nickel		5.3e-03	2.2e-03	7.6e-03	7.1	ND	ND	0.0e+00	0.0
Silver		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Zinc		2.4e-03	3.0e-03	5.3e-03	5.0	ND	ND	0.0e+00	0.0
	Totals	6.0e-02	4.6e-02	1.1e-01	100.0	4.2e-05	4.0e-06	4.6e-05	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Table O-2

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

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Table O-3

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Kishwaukee Creek

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS				CANCER RISKS			
		Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS									
Zinc		2.2e-04	2.2e-05	2.4e-04	13.5	ND	ND	0.0e+00	0.0
	Totals	1.7e-03	4.7e-05	1.8e-03	100.0	0.0e+00	0.0e+00	0.0e+00	0.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]CC-R.w20
3/12/92
JAH/jah/TB/MWK

Table 0-4

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Wetland

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS								
Arsenic	1.8e-04	1.9e-04	3.7e-04	5.2	1.4e-08	1.5e-08	2.9e-08	100.0
Barium	1.4e-03	7.6e-05	1.4e-03	19.9	ND	ND	0.0e+00	0.0
Copper	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Lead (1)	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Manganese	3.4e-03	1.5e-04	3.6e-03	49.8	ND	ND	0.0e+00	0.0
Nickel	1.5e-03	1.7e-04	1.7e-03	23.3	ND	ND	0.0e+00	0.0
Zinc	9.4e-05	3.2e-05	1.3e-04	1.7	ND	ND	0.0e+00	0.0
	6.6e-03	6.2e-04	7.2e-03	100.0	1.4e-08	1.5e-08	2.9e-08	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

Footnote:

(1) The U.S.EPA's lead uptake/biokinetic model was used to assess the risks associated with surface water lead exposure. Refer to section 8.5.3 of the baseline risk assessment for a discussion of the health risks associated with lead exposure.

[woodstock.2020.RA]CD-R.w20
3/12/92
JAH/jah/TB/MWK

Table O-5

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Kishwaukee Creek

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS				CANCER RISKS			
		Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS									
Chromium VI		1.5e-03	1.7e-04	1.7e-03	7.7	ND	ND	0.0e+00	0.0
Cobalt (1)		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Copper (1)		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Nickel		3.0e-03	6.8e-05	3.0e-03	13.8	ND	ND	0.0e+00	0.0
Zinc		1.8e-03	1.2e-04	1.9e-03	8.6	ND	ND	0.0e+00	0.0
	Totals	2.1e-02	5.1e-04	2.2e-02	100.0	0.0e+00	0.0e+00	0.0e+00	0.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

Footnote:

(1) The risk associated with exposure to this metal could not be quantitated because a U.S.EPA toxicity value was not available. Refer to section 8.5.3 of the baseline risk assessment for a qualitative discusion of the risk associated with this metal.

[woodstock.2020.RA]CE-R.w20
3/12/92
JAH/jah/TB/MWK

Table 0-6

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Wetlands

Population: Trespasser
Land Use: Current Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
VOLATILES								
2-Butanone	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Toluene	2.9e-06	2.2e-08	2.9e-06	0.0	ND	ND	0.0e+00	0.0
SEMIVOLATILES								
Phenol	1.3e-05	8.8e-08	1.3e-05	0.0	ND	ND	0.0e+00	0.0
1,2-Dichlorobenzene	1.4e-05	5.3e-08	1.4e-05	0.0	ND	ND	0.0e+00	0.0
4-Methylphenol	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzoic Acid	3.9e-07	2.3e-09	4.0e-07	0.0	ND	ND	0.0e+00	0.0
Fluoranthene	3.7e-05	1.4e-07	3.7e-05	0.0	ND	ND	0.0e+00	0.0
bis(2-ethylhexyl)phthalate	1.5e-03	2.9e-06	1.5e-03	0.6	6.0e-08	1.2e-10	6.0e-08	100.0
METALS								
Chromium VI								
Copper	3.4e-03	4.0e-04	3.8e-03	1.5	ND	ND	0.0e+00	0.0
Mercury	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Nickel	1.4e-03	4.8e-05	1.4e-03	0.5	ND	ND	0.0e+00	0.0
Selenium	2.8e-02	6.6e-04	2.9e-02	11.1	ND	ND	0.0e+00	0.0
Thallium	1.2e-04	2.8e-05	1.5e-04	0.1	ND	ND	0.0e+00	0.0
Zinc	2.2e-01	2.5e-03	2.2e-01	85.0	ND	ND	0.0e+00	0.0
	2.8e-03	1.9e-04	3.0e-03	1.1	ND	ND	0.0e+00	0.0
Totals	2.6e-01	3.9e-03	2.6e-01	100.0	6.0e-08	1.2e-10	6.0e-08	100.0

Notes:
A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:
Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]CF-R.w20
3/10/92

Table O-7

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: Off-Site Residents
Land Use: Current Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS		CANCER RISKS	
		Inhalation	% of Total	Inhalation	% of Total
VOLATILES					
Chloroethane		5.0e-06	0.2	ND	0
Benzene		ND	0.0	1.0e-07	100
Toluene		2.8e-06	0.1	ND	0
Chlorobenzene		1.3e-03	47.7	ND	0
Ethylbenzene		5.5e-05	2.0	ND	0
Xylenes (mixed)		7.4e-05	2.7	ND	0
Freon		1.3e-03	46.7	ND	0
4-Ethyl Toluene		4.6e-06	0.2	ND	0
1,3,5-Trimethylbenzene		2.0e-06	0.1	ND	0
1,2,4-Trimethylbenzene		9.2e-06	0.3	ND	0
	Totals	2.7e-03	100.0	1.0e-07	100.0

Notes:

(a) Toxicity values not available for Freon-114, dichlorodifluoroethane used.
(b) Toxicity values for ethyl toluene not available, toluene used instead.
(c) Toxicity values for trimethylbenzene not available, toluene used instead.

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:
Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]CG-R.w20
10/31/91
JAH/jah/TB/MWK

Table 0-8

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: Park User
Land Use: Future Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS Inhalation	HAZARD QUOTIENTS % of Total	CANCER RISKS Inhalation	CANCER RISKS % of Total
VOLATILES				
Chloroethane	4.8e-07	0.2	ND	0
Benzene	ND	0.0	9.7e-09	100
Toluene	2.7e-07	0.1	ND	0
Chlorobenzene	1.2e-04	47.7	ND	0
Ethylbenzene	5.3e-06	2.0	ND	0
Xylenes (mixed)	7.1e-06	2.7	ND	0
Freon	1.2e-04	46.7	ND	0
4-Ethyl Toluene	4.4e-07	0.2	ND	0
1,3,5-Trimethylbenzene	1.9e-07	0.1	ND	0
1,2,4-Trimethylbenzene	8.8e-07	0.3	ND	0
Totals	2.6e-04	100.0%	9.7e-09	100.0%

(a) Toxicity values not available for Freon-114, dichlorodifluoroethane used.
(b) Toxicity values for ethyl toluene not available, toluene used instead.
(c) Toxicity values for trimethylbenzene not available, toluene used instead.

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FA-R.w20
10/31/91
JAH/jah/TB/MWK

Table O-9

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Soil
Source Area: Landfill

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
SEMIVOLATILES								
4-Chloroaniline	6.1e-04	3.5e-05	6.5e-04	0.7	ND	ND	0.0e+00	0.0
Dimethylphthalate	1.2e-06	7.0e-08	1.3e-06	0.0	ND	ND	0.0e+00	0.0
Phenanthrene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Di-n-butylphthalate	1.6e-05	1.7e-06	1.8e-05	0.0	ND	ND	0.0e+00	0.0
Fluoranthene	6.8e-05	3.9e-06	7.1e-05	0.1	ND	ND	0.0e+00	0.0
Pyrene	1.1e-04	6.1e-06	1.1e-04	0.1	ND	ND	0.0e+00	0.0
Butylbenzylphthalate	9.9e-06	1.0e-06	1.1e-05	0.0	ND	ND	0.0e+00	0.0
Benzo(a)anthracene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Chrysene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(b)fluoranthene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(k)fluoranthene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(a)pyrene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Ideno(1,2,3-cd)pyrene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Dibenz(a,h)anthracene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(g,h,i)perylene	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Total Carcinogenic PAHs	ND	ND	0.0e+00	0.0	1.2e-04	7.1e-06	1.3e-04	97.3
METALS								
Barium	2.4e-02	4.1e-03	2.8e-02	29.2	ND	ND	0.0e+00	0.0
Cadmium (food/soil)	6.7e-03	1.6e-03	8.3e-03	8.6	ND	ND	0.0e+00	0.0
Chromium VI	6.1e-03	1.1e-02	1.7e-02	17.3	ND	ND	0.0e+00	0.0
Copper	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Mercury	1.0e-02	5.1e-03	1.5e-02	15.7	ND	ND	0.0e+00	0.0
Nickel	5.3e-03	1.8e-03	7.1e-03	7.3	ND	ND	0.0e+00	0.0
Silver	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Zinc	2.3e-03	2.4e-03	4.8e-03	4.9	ND	ND	0.0e+00	0.0
Totals	5.9e-02	3.8e-02	9.7e-02	100.0	1.2e-04	9.8e-06	1.3e-04	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Table 0-9

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FB-R.w20
3/12/92
JAH/jah/TB/MWK

Table O-10

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Kishwaukee Creek

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS								
Zinc	2.3e-04	1.5e-05	2.5e-04	13.1	ND	ND	0.0e+00	0.0
	1.9e-03	3.2e-05	1.9e-03	100.0	0.0e+00	0.0e+00	0.0e+00	0.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FC-R.w20
3/12/92
JAH/jah/TB/MWK

Table O-11

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Wetlands

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS								
Arsenic	6.5e-04	1.3e-04	7.8e-04	3.2	1.5e-07	3.0e-08	1.8e-07	100.0
Barium	4.9e-03	5.2e-05	5.0e-03	20.5	ND	ND	0.0e+00	0.0
Copper	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Lead (1)	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Manganese	1.2e-02	1.0e-04	1.3e-02	51.7	ND	ND	0.0e+00	0.0
Nickel	5.5e-03	1.1e-04	5.6e-03	23.0	ND	ND	0.0e+00	0.0
Zinc	3.4e-04	2.1e-05	3.6e-04	1.5	ND	ND	0.0e+00	0.0
Total	2.4e-02	4.2e-04	2.4e-02	100.0	1.5e-07	3.0e-08	1.8e-07	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

Footnote:

(1) The U.S.EPA's lead uptake/biokinetic model was used to assess the risks associated with surface water lead exposure. Refer to section 8.5.3 of the baseline risk assessment for a discussion of the health risks associated with lead exposure.

[woodstock.2020.RA]FD-R.w20
3/12/92
JAH/jah/TB/MWK

Table O-12

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Kishwaukee Creek

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS				CANCER RISKS			
		Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS									
Chromium VI		1.5e-03	1.4e-04	1.6e-03	7.6	ND	ND	0.0e+00	
Cobalt (1)		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	
Copper (1)		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	
Nickel		2.9e-03	5.6e-05	3.0e-03	13.8	ND	ND	0.0e+00	
Zinc		1.7e-03	1.0e-04	1.8e-03	8.6	ND	ND	0.0e+00	
	Totals	2.1e-02	4.1e-04	2.2e-02	100.0	0.0e+00	0.0e+00	0.0e+00	

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:
Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

Footnote:

(1) The risk associated with exposure to this metal could not be quantitated because a U.S.EPA toxicity value was not available. Refer to section 8.5.3 of the baseline risk assessment for a qualitative discusion of the risk associated with this metal.

[woodstock.2020.RA]FE-R.w20
3/12/92
JAH/jah/TB/MWK

Table 0-13

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Wetland

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	*Ingestion*	*Total*	*% of Total*	*Dermal Absorp.*	*Ingestion*	*Total*	*% of Total*
VOLATILES								
2-Butanone	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Toluene	2.8e-06	1.8e-08	2.8e-06	0.0	ND	ND	0.0e+00	0.0
SEMIVOLATILES								
Phenol	1.3e-05	7.2e-08	1.3e-05	0.0	ND	ND	0.0e+00	0.0
1,2-Dichlorobenzene	1.4e-05	4.3e-08	1.4e-05	0.0	ND	ND	0.0e+00	0.0
4-Methylphenol	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzoic Acid	3.9e-07	1.9e-09	3.9e-07	0.0	ND	ND	0.0e+00	0.0
Fluoranthene	3.7e-05	1.2e-07	3.7e-05	0.0	ND	ND	0.0e+00	0.0
bis(2-ethylhexyl)phthalate	1.5e-03	2.3e-06	1.5e-03	0.6	1.8e-07	2.8e-10	1.8e-07	100.0
METALS								
Chromium VI	3.4e-03	3.2e-04	3.7e-03	1.4	ND	ND	0.0e+00	0.0
Copper	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Mercury	1.4e-03	3.9e-05	1.4e-03	0.5	ND	ND	0.0e+00	0.0
Nickel	2.8e-02	5.3e-04	2.9e-02	11.1	ND	ND	0.0e+00	0.0
Selenium	1.2e-04	2.3e-05	1.4e-04	0.1	ND	ND	0.0e+00	0.0
Thallium	2.2e-01	2.1e-03	2.2e-01	85.1	ND	ND	0.0e+00	0.0
Zinc	2.7e-03	1.6e-04	2.9e-03	1.1	ND	ND	0.0e+00	0.0
Total	2.5e-01	3.1e-03	2.6e-01	100.0	1.8e-07	2.8e-10	1.8e-07	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Table 0-13

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FF-R.w20
3/10/92
JAH/jah/TB/MWK

Table O-14

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: On-Site resident
Land Use: Future Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS Inhalation	HAZARD QUOTIENTS % of Total	CANCER RISKS Inhalation	CANCER RISKS % of Total
VOLATILES				
Chloroethane	5.0e-06	0.2	ND	0
Benzene	ND	0.0	1.0e-07	100
Toluene	2.8e-06	0.1	ND	0
Chlorobenzene	1.3e-03	47.7	ND	0
Ethylbenzene	5.5e-05	2.0	ND	0
Xylenes (mixed)	7.4e-05	2.7	ND	0
Freon	1.3e-03	46.7	ND	0
4-Ethyl Toluene	4.6e-06	0.2	ND	0
1,3,5-Trimethylbenzene	2.0e-06	0.1	ND	0
1,2,4-Trimethylbenzene	9.2e-06	0.3	ND	0
Totals	2.7e-03	100.0	1.0e-07	100.0

(a) Toxicity values not available for Freon-114, dichlorodifluoroethane used.
(b) Toxicity values for ethyl toluene not available, toluene used instead.
(c) Toxicity values for trimethylbenzene not available, toluene used instead.

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FG-R.w20
10/31/91
JAH/jah/TB/MWK

Table O-15

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Soil
Source Area: Landfill

Population: On-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS				CANCER RISKS			
		Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
SEMIVOLATILES									
4-Chloroaniline		1.5e-03	8.8e-05	1.6e-03	0.7	ND	ND	0.0e+00	0.0
Dimethylphthalate		3.1e-06	1.8e-07	3.2e-06	0.0	ND	ND	0.0e+00	0.0
Phenanthrene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Di-n-butylphthalate		4.1e-05	4.2e-06	4.5e-05	0.0	ND	ND	0.0e+00	0.0
Fluoranthene		1.7e-04	9.7e-06	1.8e-04	0.1	ND	ND	0.0e+00	0.0
Pyrene		2.7e-04	1.5e-05	2.8e-04	0.1	ND	ND	0.0e+00	0.0
Butylbenzylphthalate		2.5e-05	2.5e-06	2.7e-05	0.0	ND	ND	0.0e+00	0.0
Benzo(a)anthracene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Chrysene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(b)fluoranthene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(k)fluoranthene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(a)pyrene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Ideno(1,2,3-cd)pyrene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Dibenz(a,h)anthracene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzo(g,h,i)perylene		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Total Carcinogenic PAHs		ND	ND	0.0e+00	0.0	3.1e-04	1.8e-05	3.3e-04	97.3
METALS									
Barium		6.0e-02	1.0e-02	7.1e-02	29.2	ND	ND	0.0e+00	0.0
Cadmium (food/soil)		1.7e-02	4.0e-03	2.1e-02	8.6	ND	ND	0.0e+00	0.0
Chromium VI		1.5e-02	2.6e-02	4.2e-02	17.3	ND	ND	0.0e+00	0.0
Copper		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Mercury		2.5e-02	1.3e-02	3.8e-02	15.7	ND	ND	0.0e+00	0.0
Nickel		1.3e-02	4.5e-03	1.8e-02	7.3	ND	ND	0.0e+00	0.0
Silver		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Zinc		5.9e-03	6.0e-03	1.2e-02	4.9	ND	ND	0.0e+00	0.0
	Totals	1.5e-01	9.4e-02	2.4e-01	100.0	3.1e-04	2.5e-05	3.3e-04	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Table O-15

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose

Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FH-R.w20
3/12/92
JAH/jah/TB/MWK

Table O-16

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FI-R.w20
3/12/92
JAH/jah/TB/MWK

Table 0-17

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Leachate as Groundwater
Source Area: Landfill

Population: On-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POT[illegible] CONCE[illegible]	HAZARD QUOTIENTS					CANCER RISKS				
	Dermal Absorp.	Ingestion	Inhalation	Total	% of Total	Dermal Absorp.	Ingestion	Inhalation	Total	% of Total
VOLATILES										
1,2-Dichloroethene (trans)	4.8e-03	2.6e-02	ND	3.1e-02	0.0	ND	ND	ND	0.0e+00	0.0
Benzene	ND	ND	ND	0.0e+00	0.0	1.3e-07	5.7e-06	2.4e-06	8.2e-06	0.2
Tol[illegible]	6.0e-05	3.3e-04	1.4e-05	4.0e-04	0.0	ND	ND	ND	0.0e+00	0.0
Chlo[illegible]	7.9e-03	1.3e-02	2.2e-02	4.3e-02	0.0	ND	ND	ND	0.0e+00	0.0
Xylenes (mixed)	4.7e-06	1.3e-04	3.7e-04	5.1e-04	0.0	ND	ND	ND	0.0e+00	0.0
SEMIVOLATILES										
1,4-Dichlorobenzene	ND	ND	8.9e-05	8.9e-05	0.0	1.2e-08	2.7e-06	ND	2.7e-06	0.1
4-Methyl[illegible]	ND	ND	ND	0.0e+00	0.0	ND	ND	ND	0.0e+00	0.0
B[illegible]	2.7e-06	4.4e-04	ND	4.4e-04	0.0	ND	ND	ND	0.0e+00	0.0
[illegible]	1.5e-03	2.8e-01	ND	2.8e-01	0.2	ND	ND	ND	0.0e+00	0.0
Pent[illegible]	1.6e-05	3.3e-03	ND	3.3e-03	0.0	2.5e-08	5.0e-06	ND	5.0e-06	0.1
METALS										
Antimony	1.3e-01	2.4e+00	ND	2.6e+00	1.9	ND	ND	ND	0.0e+00	0.0
Arsenic	3.2e-02	1.1e+01	ND	1.1e+01	8.4	7.3e-06	2.6e-03	ND	2.6e-03	63.7
Barium	2.7e-01	5.0e+00	ND	5.3e+00	4.0	ND	ND	ND	0.0e+00	0.0
Beryllium	4.2e-03	1.5e-01	ND	1.6e-01	0.1	3.8e-05	1.4e-03	ND	1.4e-03	35.9
Cadmium (water)	8.4e-01	2.2e+01	ND	2.2e+01	17.0	ND	ND	ND	0.0e+00	0.0
Chromium VI	6.9e-02	9.1e+00	ND	9.2e+00	6.9	ND	ND	ND	0.0e+00	0.0
Cobalt	ND	ND	ND	0.0e+00	0.0	ND	ND	ND	0.0e+00	0.0
Copper	ND	ND	ND	0.0e+00	0.0	ND	ND	ND	0.0e+00	0.0
Lead	ND	ND	ND	0.0e+00	0.0	ND	ND	ND	0.0e+00	0.0
Manganese	6.9e-01	1.0e+01	ND	1.1e+01	8.2	ND	ND	ND	0.0e+00	0.0
Mercury	1.1e-02	6.2e-01	ND	6.3e-01	0.5	ND	ND	ND	0.0e+00	0.0
Nickel	6.6e-01	2.4e+01	ND	2.5e+01	19.0	ND	ND	ND	0.0e+00	0.0
Selenium	3.6e-04	1.3e-01	ND	1.3e-01	0.1	ND	ND	ND	0.0e+00	0.0
Silver	ND	ND	ND	0.0e+00	0.0	ND	ND	ND	0.0e+00	0.0
Thallium	3.9e-01	7.1e+00	ND	7.5e+00	5.7	ND	ND	ND	0.0e+00	0.0
Vanadium	3.3e-01	6.1e+00	ND	6.5e+00	4.9	ND	ND	ND	0.0e+00	0.0
Zinc	2.7e-01	3.0e+01	ND	3.0e+01	23.0	ND	ND	ND	0.0e+00	0.0
Cyanide	3.8e-04	9.8e-02	ND	9.8e-02	0.1	ND	ND	ND	0.0e+00	0.0
Totals	3.7e+00	1.3e+02	2.3e-02	1.3e+02	100.0	4.6e-05	4.0e-03	2.4e-06	4.0e-03	100.0

Table O-17

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FJ-R.w20
3/18/92
JAH/jah/TB/MWK

Table O-18

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Kishwaukee Creek

Population: On-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS								
Zinc	4.0e-04	2.5e-05	4.3e-04	13.1	ND	ND	0.0e+00	0.0
	3.2e-03	5.4e-05	3.2e-03	100.0	0.0e+00	0.0e+00	0.0e+00	0.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FK-R.w20
3/12/92
JAH/jah/TB/MWK

Table O-19

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Wetlands

Population: On-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS								
Arsenic	1.1e-03	2.2e-04	1.3e-03	3.2	2.6e-07	5.2e-08	3.1e-07	100.0
Barium	8.4e-03	8.8e-05	8.5e-03	20.5	ND	ND	0.0e+00	0.0
Copper	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Lead (1)	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Manganese	2.1e-02	1.8e-04	2.1e-02	51.7	ND	ND	0.0e+00	0.0
Nickel	9.4e-03	2.0e-04	9.6e-03	23.0	ND	ND	0.0e+00	0.0
Zinc	5.8e-04	3.7e-05	6.2e-04	1.5	ND	ND	0.0e+00	0.0
	4.1e-02	7.2e-04	4.1e-02	100.0	2.6e-07	5.2e-08	3.1e-07	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

Footnote:
(1) The U.S.EPA's lead uptake/biokinetic model was used to assess the risks associated with surface water lead exposure. Refer to section 8.5.3 of the baseline risk assessment for a discussion of the health risks associated with lead exposure.

[woodstock.2020.RA]FL-R.w20
3/12/92
JAH/jah/TB/MWK

Table O-20

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Kishwaukee Creek

Population: On-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS				CANCER RISKS			
		Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS									
Chromium VI		2.6e-03	2.4e-04	2.8e-03	7.6	ND	ND	0.0e+00	
Cobalt (1)		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	
Copper (1)		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	
Nickel		5.0e-03	9.5e-05	5.1e-03	13.8	ND	ND	0.0e+00	
Zinc		3.0e-03	1.7e-04	3.2e-03	8.6	ND	ND	0.0e+00	
	Totals	3.6e-02	7.1e-04	3.7e-02	100.0	0.0e+00	0.0e+00	0.0e+00	

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

Footnote:

(1) The risk associated with exposure to this metal could not be quantitated because a U.S.EPA toxicity value was not available. Refer to section 8.5.3 of the baseline risk assessment for a qualitative discusion of the risk associated with this metal.

[woodstock.2020.RA]FM-R.w20
3/12/92
JAH/jah/TB/MWK

Table O-21

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Wetlands

Population: On-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
VOLATILES								
2-Butanone	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Toluene	7.1e-06	4.5e-08	7.1e-06	0.0	ND	ND	0.0e+00	0.0
SEMIVOLATILES								
Phenol	3.1e-05	1.8e-07	3.1e-05	0.0	ND	ND	0.0e+00	0.0
1,2-Dichlorobenzene	3.4e-05	1.1e-07	3.4e-05	0.0	ND	ND	0.0e+00	0.0
4-Methylphenol	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzoic Acid	9.7e-07	4.6e-09	9.8e-07	0.0	ND	ND	0.0e+00	0.0
Fluoranthene	9.2e-05	2.9e-07	9.2e-05	0.0	ND	ND	0.0e+00	0.0
bis(2-ethylhexyl)phthalate	3.7e-03	5.9e-06	3.7e-03	0.6	4.4e-07	7.0e-10	4.4e-07	100.0
METALS								
Chromium VI	8.5e-03	8.1e-04	9.3e-03	1.4	ND	ND	0.0e+00	0.0
Copper	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Mercury	3.4e-03	9.8e-05	3.5e-03	0.5	ND	ND	0.0e+00	0.0
Nickel	7.0e-02	1.3e-03	7.1e-02	11.1	ND	ND	0.0e+00	0.0
Selenium	3.0e-04	5.7e-05	3.5e-04	0.1	ND	ND	0.0e+00	0.0
Thallium	5.4e-01	5.2e-03	5.5e-01	85.1	ND	ND	0.0e+00	0.0
Zinc	6.9e-03	3.9e-04	7.3e-03	1.1	ND	ND	0.0e+00	0.0
Total	6.3e-01	7.9e-03	6.4e-01	100.0	4.4e-07	7.0e-10	4.4e-07	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are

Table 0-21

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FN-R.w20
3/10/92
JAH/jah/TB/MWK

Table O-22

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Indoor Air
Source Area: Landfill Gas

Population: On-site Resident
Land Use: Future Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS		CANCER RISKS	
		Inhalation	% of Total	Inhalation	% of Total
VOLATILES					
Chloroethane		1.5e-02	0.2	ND	0
Benzene		ND	0.0	3.0e-04	100
Toluene		8.3e-03	0.1	ND	0
Chlorobenzene		3.8e+00	47.6	ND	0
Ethylbenzene		1.6e-01	2.0	ND	0
Xylenes (mixed)		2.2e-01	2.7	ND	0
Freon		3.7e+00	46.8	ND	0
4-Ethyl Toluene		1.3e-02	0.2	ND	0
1,3,5-Trimethylbenzene		5.9e-03	0.1	ND	0
1,2,4-Trimethylbenzene		2.7e-02	0.3	ND	0
	Totals	7.9e+00	100%	3.0e-04	100.0%

Notes:

(a) Toxicity values not available for Freon-114, dichlorodifluoroethane used.
(b) Toxicity values for ethyl toluene not available, toluene used instead.
(c) Toxicity values for trimethylbenzene not available, toluene used instead.

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:
Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FS-R.w20
6/10/92
JAH/jah/TB/MWK

Table O-23

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site   Remedial Investigation
Woodstock, Illinois

Medium: Ambient Air
Source Area: Landfill Gas

Population: Off-Site Resident
Land Use: Future Land Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS		CANCER RISKS	
		Inhalation	% of Total	Inhalation	% of Total
VOLATILES					
Chloroethane		5.0e-06	0.2	ND	0
Benzene		ND	0.0	1.0e-07	100
Toluene		2.8e-06	0.1	ND	0
Chlorobenzene		1.3e-03	47.7	ND	0
Ethylbenzene		5.5e-05	2.0	ND	0
Xylenes (mixed)		7.4e-05	2.7	ND	0
Freon		1.3e-03	46.7	ND	0
4-Ethyl Toluene		4.6e-06	0.2	ND	0
1,3,5-Trimethylbenzene		2.0e-06	0.1	ND	0
1,2,4-Trimethylbenzene		9.2e-06	0.3	ND	0
	Totals	2.7e-03	100.0%	1.0e-07	100.0%

(a) Toxicity values not available for Freon-114, dichlorodifluoroethane used.
(b) Toxicity values for ethyl toluene not available, toluene used instead.
(c) Toxicity values for trimethylbenzene not available, toluene used instead.

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FO-R.w20
10/31/91
JAH/jah/TB/MWK

Table O-24

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Groundwater
Source Area: Upper Aquifer

Population: Off-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS					CANCER RISKS				
	Dermal Absorp.	Ingestion	Inhalation	Total	% of Total	Dermal Absorp.	Ingestion	Inhalation	Total	% of Total
VOLATILES										
Vinyl chloride	ND	ND	ND	0.0e+00	0.0	1.0e-04	5.6e-04	3.7e-05	7.0e-04	58.8
Acetone	3.0e-04	1.6e-03	ND	1.9e-03	0.1	ND	ND	ND	0.0e+00	0.0
1,2-Dichloroethene (trans)	8.9e-04	4.9e-03	ND	5.8e-03	0.2	ND	ND	ND	0.0e+00	0.0
Benzene	ND	ND	ND	0.0e+00	0.0	3.3e-08	1.6e-06	7.0e-07	2.3e-06	0.2
SEMIVOLATILES										
bis(2-ethylhexyl)phthalate	1.7e-07	8.1e-03	ND	8.1e-03	0.2	2.0e-11	9.8e-07	ND	9.8e-07	0.1
METALS										
Antimony	3.0e-02	5.5e-01	ND	5.8e-01	16.5	ND	ND	ND	0.0e+00	0.0
Arsenic	6.0e-03	2.1e+00	ND	2.1e+00	59.0	1.4e-06	4.8e-04	ND	4.8e-04	40.9
Vanadium	1.4e-03	2.6e-02	ND	2.7e-02	0.8	ND	ND	ND	0.0e+00	0.0
Cyanide	8.2e-05	2.1e-02	ND	2.1e-02	0.6	ND	ND	ND	0.0e+00	0.0
Total	7.9e-02	3.5e+00	0	3.5e+00	100.0	1.0e-04	1.0e-03	0.00003797	1.2e-03	100.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:
Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FP-R.w20
3/12/92
JAH/jah/TB/MWK

Table 0-25

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Surface Water
Source Area: Kishwaukee Creek

Population: Off-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS				CANCER RISKS			
		Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS									
Zinc		4.0e-04	5.0e-05	4.5e-04	100.0	ND	ND	0.0e+00	0.0
	Totals	4.0e-04	5.0e-05	4.5e-04	100.0	0.0e+00	0.0e+00	0.0e+00	0.0

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:
Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FQ-R.w20
6/8/92
JAH/jah/TB/MWK

Table O-26

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Sediment
Source Area: Kishwaukee Creek

Population: Off-Site Resident
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN		HAZARD QUOTIENTS				CANCER RISKS			
		Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
METALS									
Chromium VI		2.6e-03	4.9e-04	3.0e-03	8.1	ND	ND	0.0e+00	
Cobalt (1)		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	
Copper (1)		ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	
Nickel		5.0e-03	1.9e-04	5.2e-03	13.8	ND	ND	0.0e+00	
Zinc		3.0e-03	3.4e-04	3.3e-03	8.9	ND	ND	0.0e+00	
	Total	3.6e-02	1.4e-03	3.8e-02	100.0	0.0e+00	0.0e+00	0.0e+00	

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

Footnotes:

(1) The risk associated with exposure to this metal could not be quantitated because a U.S.EPA toxicity value was not available. Refer to section 8.5.3 of the baseline risk assessment for a qualitative discusion of the risk associated with this metal.

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3/12/92
JAH/jah/TB/MWK

Table 0-27

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Leachate
Source Area: Groundwater

Population: Park User
Land Use: Future Use Scenario

CHEMICAL OF POTENTIAL CONCERN	HAZARD QUOTIENTS				CANCER RISKS			
	Dermal Absorp.	Ingestion	Total	% of Total	Dermal Absorp.	Ingestion	Total	% of Total
VOLATILES								
1,2-Dichloroethene (trans)	ND	2.6e-03	2.6e-03	0.0	ND	ND	0.0e+00	0.0
Benzene	ND	ND	0.0e+00	0.0	ND	5.7e-07	5.7e-07	0.1
Toluene	ND	3.3e-05	3.3e-05	0.0	ND	ND	0.0e+00	0.0
Chlorobenzene	ND	1.3e-03	1.3e-03	0.0	ND	ND	0.0e+00	0.0
Xylenes (mixed)	ND	1.3e-05	1.3e-05	0.0	ND	ND	0.0e+00	0.0
SEMIVOLATILES								
1,4-Dichlorobenzene	ND	ND	0.0e+00	0.0	ND	2.7e-07	2.7e-07	0.1
4-Methylphenol	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Benzoic Acid	ND	4.4e-05	4.4e-05	0.0	ND	ND	0.0e+00	0.0
Naphthalene	ND	2.8e-02	2.8e-02	0.2	ND	ND	0.0e+00	0.0
Pentachlorophenol	ND	3.3e-04	3.3e-04	0.0	ND	5.0e-07	5.0e-07	0.1
METALS								
Antimony	ND	2.4e-01	2.4e-01	1.9	ND	ND	0.0e+00	0.0
Arsenic	ND	1.1e+00	1.1e+00	8.6	ND	2.6e-04	2.6e-04	64.3
Barium	ND	5.0e-01	5.0e-01	3.9	ND	ND	0.0e+00	0.0
Beryllium	ND	1.5e-02	1.5e-02	0.1	ND	1.4e-04	1.4e-04	35.4
Cadmium (water)	ND	2.2e+00	2.2e+00	16.9	ND	ND	0.0e+00	0.0
Chromium VI	ND	9.1e-01	9.1e-01	7.1	ND	ND	0.0e+00	0.0
Cobalt	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Copper	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Lead	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Manganese	ND	1.0e+00	1.0e+00	7.9	ND	ND	0.0e+00	0.0
Mercury	ND	6.2e-02	6.2e-02	0.5	ND	ND	0.0e+00	0.0
Nickel	ND	2.4e+00	2.4e+00	19.0	ND	ND	0.0e+00	0.0
Selenium	ND	1.3e-02	1.3e-02	0.1	ND	ND	0.0e+00	0.0
Silver	ND	ND	0.0e+00	0.0	ND	ND	0.0e+00	0.0
Thallium	ND	7.1e-01	7.1e-01	5.5	ND	ND	0.0e+00	0.0
Vanadium	ND	6.1e-01	6.1e-01	4.8	ND	ND	0.0e+00	0.0
Zinc	ND	3.0e+00	3.0e+00	23.4	ND	ND	0.0e+00	0.0
Cyanide	ND	9.8e-03	9.8e-03	0.1	ND	ND	0.0e+00	0.0
Totals	0.0e+00	1.3e+01	1.3e+01	100.0	0.0e+00	4.0e-04	4.0e-04	100.0

Table 0-27

SUMMARY OF NONCANCER HAZARDS AND CANCER RISKS

Woodstock Landfill NPL Site Remedial Investigation
Woodstock, Illinois

Medium: Leachate
Source Area: Groundwater

Population: Park User
Land Use: Future Use Scenario

Notes:

A noncancer risk estimate (HQ) of greater than 1 indicates the potential for noncancer effects (e.g., liver disease) to occur in humans exposed at an assumed level and duration to a contaminated medium. A cancer risk level of greater than 1.0e-06 (i.e., one in a million) is above the U.S. EPA's point of departure for Superfund sites.

Hazard quotients and cancer risks are unitless values which represent the probability of incurring an adverse health effect. These risk values are calculated using the following relationships:

Hazard Quotient = Chronic Daily Intake / Reference Dose
Cancer Risk = Chronic Daily Intake x Slope Factor

Hazard quotients and cancer risks are summarized for applicable routes of exposure. Values for each route are summed to arrive at an exposure pathway total risk value. The percentage of total risk is also shown for each compound.

In some cases risks were not determined (ND) because reference doses or slope factors were not available.

[woodstock.2020.RA]FT-R.w20
3/10/92
JAH/jah/

Appendix A: Derivation of Equations

Nature of Volatilization Process

To assess the potential for VOC's to volatilize from water used indoors, it is useful to consider the equilibrium and rate processes involved. The relevant relationship describing the volatilization of a chemical and its subsequent equilibrium between the air and water phases is Henry's law

$$H = C_a/C_w \quad (1)$$

where H is the dimensionless Henry's law constant, and C_a and C_w (mass/volume) are the concentrations of the volatilized chemical in the air and water phases, respectively, at equilibrium.

Table 5 is a list of H constants at 25 °C for several organic chemicals of environmental concern, along with their vapor pressures and solubilities, the values being approximate, either calculated or taken directly from the compilation by Mackay and Shiu [19]. The H constants shown there encompass a range greater than five orders of magnitude. Their vapor pressures and water solubilities are also quite different. Since the H values are predicted fairly well by the ratio of the vapor pressure of the pure material to its aqueous solubility, compounds such as carbon tetrachloride and tetrachloroethylene, with quite different solubilities and vapor pressures, can nevertheless have similar H values. Also it is essential to recognize that even a low vapor-pressure chemical, by virtue of its low solubility in water, has the potential to volatilize to the same extent as a high vapor-pressure chemical.

The maximum extent to which a chemical may be expected to volatilize in the home from indoor water uses can be estimated by considering the average quantities of water used within a home, F_w (L/h), along with typical air flow or infiltration rates F_a (L/h). For a family of four a typical ratio of F_a/F_w may be taken as 10^4 [4]. The ratio of masses of volatilized chemicals, r, in the two phases is given by

$$r = (C_a/C_w)(V_a/V_w) \quad (2)$$

where V_a and V_w are the quantities of air and water, respectively, used in a given period of time in the home. In the steady-state one can assume that V_a/V_w equals F_a/F_w, and r_{MAX} is the maximum expected value for r when C_a/C_w equals H, such that

$$r_{MAX} = H(F_a/F_w) = 10^4 \ H \quad (3.$$

This indicates that in the steady-state, as water is used within the typical home and air infiltrates through it, for a chemical with an H value as low as 10^{-4}, r_{MAX} is unity, or about 50% volatilization will occur. Since all the chemicals in Table 5 have H values greater than 10^{-4}, in each case, assuming Henry's law equilibrium is attained, one would expect substantial volatilization to occur in the home from normal uses of contaminated water as it is exposed to the indoor air.

The H constant will increase with temperature. Munz and Roberts [20] showed that for several volatile organic chemicals the temperature effect is given by

$$\log H = A' - B'/T \tag{4}$$

where A' and B' are constants for each chemical, and T is absolute temperature. For chloroform the measured A' and B' values were found to be 4.990 and 1729, respectively; and for carbon tetrachloride, 5.853 and 1718, respectively, the measurements being taken over the range of 10 to 30 °C. For example, using this equation for chloroform, the H values are 0.076 and 0.19 at 10 °C and 30 °C, respectively, The comparable values for carbon tetrachloride are 0.606 and 1.52. Thus the maximum extent of volatilization that can occur will increase markedly with temperature.

As discussed by Mackay and Yeun [21], the rate of volatilization of a chemical from water is dependent on its molecular-diffusivity properties. Often a two-resistance model is used to describe the process in which the volatilizing chemical has to first diffuse across a liquid film at the air water interface, followed by diffusion across the air film. Mackay and Yeun measured volatilization rates in a wind wave ta k for 11 organic compounds with varying Henry's law constants. They confirmed the validity of the two-resistance model, and showed the effects of solute diffusivity and temperature. The chemicals studied included several halogenated VOC's, including chlorobenzene, carbon tetrachloride, 1,2-dibromoethane, and 1,2 dichloropropane, as well as benzene and toluene, and several ketones and alcohols. They showed that no interactions occur when solutes volatilize simultaneously, and concluded that the mass-transfer rate was predominantly liquid-phase resistant for many of these chemicals.

The two-resistance model expressing the mass flux, F_m (mol/m^2s), can be written as

$$F_m = K(C_w - C_a/H) \qquad (5$$

where K is the overall, two-resistance mass-transfer coefficient (m/s), C_a is the solute concentration in air (mol/m^3) and C_w that in water. The overall mass transfer is a product of the flux and the surface area exposed, so that, for example, small droplets in a shower with a greater surface area would be expected to have a greater rate of volatilization per unit time than would the same mass of larger droplets with a lower surface area/mass ratio.

Mackay and Yeun concluded that the mass-transfer coefficient in either the liquid or gas phase was most likely dependent on the Schmidt number, Sc, which is the dimensionless ratio of viscosity/(density x diffusivity), in the respective phase. The two-resistance model describes the K in terms of liquid and gas phase transfer coefficients, K_L and K_G, respectively, such that

$$1/K = 1/K_L + 1/HK_G \qquad (6)$$

They showed that for their data K_L was proportional to 3.41×10^{-3} $Sc_L^{-0.5}$, while K_G was proportional to 4.62×10^{-2} $Sc_G^{-0.67}$. The Sc_G and Sc_L values for the 12 compounds did not differ greatly, ranging from 0.72-1.07 for Sc_G, and 939-1177 for Sc_L at 20 °C. However, the H values varied considerably by almost four orders of magnitude. For the smallest H-value compound, 1-butanol, the K_G term dominated to establish the overall K, while for the high H-value compounds like benzene and carbon tetrachloride, liquid-film transfer was the dominant rate-controlling step, the $1/HK_G$ term being negligible in Equation 8. The overall mass-transfer coefficients measured were thus quite different at these two extremes. For example, the ratio of mass-transfer coefficients for benzene to that of 1-butanol varied from 14 to 20. In contrast, for those compounds where K_L dominated, the K values did not vary much, as expected, since their Sc_L values were quite similar, and H no longer played a significant role in determining K. Thus, in one series of determinations of mass-transfer coefficients, Mackay and Yeun measured K values of 51.1, 51.1, and 45.3 (10^6 m/s), respectively, for benzene, carbon tetrachloride, and 1,2-dibromoethane, their Sc_L values being 1021, 1062, and 1075, respectively.

This analysis indicates that one should be able to compare and predict the K values among compounds based on fundamental molecular properties and H values, to the extent that this two-resistance model applies to the volatilization from indoor water uses. They observed that the use of the K_L dependency on $Sc_L^{-0.5}$ predicts a 2.8% temperature increase in K per degree.

Equation 5 for the mass-transfer or flux at the water air-interface predicts that when the air concentration, C_a, is negligible, meaning a small buildup of chemical in the receiving air, then the rate of mass transfer is directly proportional to the concentration of volatilizing chemical in the water. This is of importance in that one could then extrapolate the percent volatilization at a high concentration in the feed water to predict the same fractional volatilization at a low-feed concentration. At the same time, even if the buildup in the air did occur, however, and its removal were first order in concentration, one could still extrapolate to the lower feed concentration.

There is independent evidence in laboratory studies that the mass-transfer coefficient may be reasonably constant over several orders of magnitude of concentration [22]. For 1,2-dichloroethane in the range of 1 g/L to 10 ug/L the coefficient of variation of mass-transfer coefficient was found to be ± 6.31%; for 1,1,1-trichloroethane it was ± 5.42% over a range of concentration of 0.05 g/L to 30 ug/L.

In summary, the H constant will limit the maximum volatilization that can occur in indoor water uses. However, except for a few still-water systems in the home, such as water in a toilet bowl, many water uses are flowing or are of short-term duration in which the rate of volatilization will be limiting and equilibrium not reached. In those instances the mass-transfer coefficients become the principal controlling factor for the relative releases of different volatile and semi-volatile chemicals. Even here, however, the H constant is of importance in that it will influence the magnitude of the mass-transfer coefficient, as well as the extent to which the flux for volatilization at the water-air interface will be reduced as the air concentration builds up.

Finally, the water-air interfacial areas and temperatures of the water uses are critical determining factors in the rate of mass transfer; and certainly the H constants will increase with temperature as well. Thus, one can expect that since the various indoor water uses involve different quantities and flows of water, residence times in the water appliances and uses, degrees of mixing and turbulence, and temperatures, the extents of volatilization among the water uses, even for a given chemical, should vary.

Values for transfer efficiencies among water uses in a typical home have been determined for radon by Prichard and Gessell [10]. As shown in Table 6, the transfer efficiencies (percent volatilization) were found to vary from 30 to 90% among the water uses, the volume use-weighted mean being about 50%.

Laboratory Shower Experiments

We have performed studies on volatilization of chemicals from laboratory and full-size shower and bath systems in which chemicals have been added to the water [3-8]. In our typical laboratory shower experiments with chloroform shown in Figure 1 [23], the concentration of the chemical in the air pumped from the chamber is measured continuously as the shower water flows, and continues to be measured after the chemical injection is terminated, but with the shower still flowing. The peak concentrations shown in Figure 1 occur shortly after terminating the injection of chemical. In these studies we have also monitored the drainwater leaving the shower chamber for mass-balance purposes.

For this system the equation describing the rate of change of air concentration, C_a (mg/L), can be expressed as [6]

$$V_a(dC_a/dt) = k(C_w - C_a/H) - F_aC_a \qquad (7)$$

where V_a (L) is the volume of the shower chamber, C_w (mg/L) the concentration of the chemical in the feed water, F_a (L/min) the air flow rate through the chamber, and k (L/min) the volatilization mass-transfer coefficient. When the feed concentration is terminated, the volatilization source term becomes zero and Equation 7 reduces to

$$V_a(dC_a/dt) = -F_aC_a \tag{8}$$

the integrated form being

$$\ln C_a = \ln C_{a\,INITIAL} - (F_a/V_a)t \tag{9}$$

As expressed by Equation 7, we find that the volatilization source term $k(C_w - C_a/H)$ does indeed reduce significantly with time as C_a increases. For example, in the experiment with a chloroform feed of 1.84 mg/L shown in Figure 1, at 10, 30, and 50 min, the instantaneous fractional rate of volatilization, f, was 0.82, 0.70, and 0.62, respectively. This is consistent with our experimental observation that the C_a/C_w ratio for air and water leaving the chamber was found to be less than the H value for chloroform, but that the latter value of about 0.15 was gradually approached during the shower experiment [23], thus gradually inhibiting the volatilization rate.

We have also found in our experiments with both chloroform and trichloroethylene (TCE), that during the decay period (following the termination of the chemical in the shower feed) significant quantities of the volatilized chemical in the shower chamber air redissolves in the flowing water, as measured in the drainwater. Thus, Equations 8 and 9 are not quite accurate, since there is this additional decay route.

As shown in Figure 1 for chloroform, as expected the air concentration due to volatilization increases with temperature and concentration of the feed water in the shower experiments. Also as expected, we have found that increased air flow reduces the concentration of volatilized chemical in the chamber air and at the same time increases the rate of volatilization, since the rate of approach to Henry's law equilibrium is reduced. Rates of volatilization for chloroform and TCE ranged from about 50 to 90%, depending on temperature and other shower conditions, with chloroform volatilization typically lower than that for TCE.

Modeling Shower and Whole House Exposures

One can estimate the shower and whole house exposures by the use of simple, one-compartment modeling. For example, integrating Equation 7 and assuming that C_a/H is negligible compared to C_w, one obtains an expression for the change in C_a with time in a chamber

$$\ln (1 - C_a F_a / k C_w) = - (F_a/V_a) t \qquad (10)$$

The assumption that C_a/H is negligible implies that the rate of volatilization in the shower is constant. In that case it can be shown that k equals fF_w, where f is the fraction of chemical that volatilizes from the feedwater whose flow rate is F_w (V/t). Although, as noted above there is a gradual decrease in f values with time during the shower experiments, this will not substantially affect the estimated average values of C_a that will be used to calculate exposures. Using Equation 10 one can calculate the maximum air concentration that will be achieved in a one-compartment shower or bath. For small values of $(F_w/V_a)t$ (the magnitude of which will be considered below), Equation 10 reduces to a simple linear form

$$C_a = ktC_w/V_a \qquad (11)$$

Thus, after a given shower period, t, this is also the maximum concentration, C_{aMAX},

$$C_{aMAX} = ktC_w/V_a \qquad (12)$$

Also, the average concentration, C_{aAVG}, would be $C_{aMAX}/2$ since C_a increases linearly with time

$$C_{aAVG} = ktC_w/2V_a \qquad (13)$$

For the purpose of estimating possible shower exposures, it will be assumed that the concentrations during the shower period itself, as well as subsequently while a person remains in the bathroom, will be the same in the shower and bathroom. In fact, our measurements in a full-size shower show that there is indeed a difference between the two, and that the system should be more appropriately treated as a two-compartment system [24]. For precise modeling of the exposures, this difference should be considered, but as an approximation it will be neglected here.

Subsequent to the showering period there will be a decay of the air concentrations in the bathroom due to normal exchange of air. During this period the person in the bathroom will continue to be exposed to the volatilized chemicals in the air. The decay of C_a is represented by

$$\ln (C_a/C_{aMAX}) = - (F_a/V_a)t \qquad (14)$$

For small values of $(F_a/V_a)t$ this equation linearizes to

$$C_a = C_{aMAX} [1 - (F_a/V_a)t] \qquad (15)$$

The average concentration during this period, C_{aAVG}, is

$$C_{aAVG} = (C_a + C_{aMAX})/2 \qquad (16)$$

Combining Equations 15 and 16, one obtains

$$C_{aAVG} = C_{aMAX} [1 - F_a t/(2V_a)] \qquad (17$$

In many cases, the $F_a t/(2V_a)$ term in Equation 17 is likely to be substantially smaller than unity, so that as an approximation during the decay period one can assume that $C_{aAVG} = C_{aMAX}$, at least for the purposes of estimating the magnitude of inhalation exposures.

One can use these equations to estimate the C_{aAVG} values for various shower-water flow and bathroom characteristics. In an Australian survey of water uses, distributions of average shower water flow rates and duration were reported for about 2,500 households [25]. The geometric mean for the shower flow rates, F_w, was about 8 L/min (about 500 L/h), and about 6 min for the shower duration, which will be specified as t_d, and typically taken as 0.1 h. These values will be utilized here to estimate C_a values using the above equations. In a study of modern houses in one heating season the geometric mean for air exchange rates was reported to be 0.53 h^{-1} [13]. This value will be used for the bathroom, along with a value for its size, V_a, of 10,000 L.

Thus, the F_a for the bathroom will be $0.53V_a$, or about 5,000 L/h. Thus, for a shower period of 0.1 h, or a decay period of 0.2 h, with $(F_a/V_a)t$ values of 0.053 and 0.115, respectively, the approximation of linearizing Equations 10 and 14 involves errors of less than one percent.

The above equations and data can be utilized to estimate the average air concentrations to which people are exposed in bathrooms during and after showering. As discussed earlier, the fractional volatilization rate in our shower experiments has been found to range from 0.5 to 0.9, depending on the specific chemical, water temperature, and other factors. For the purposes of estimating a typical value, we will use an f value of 0.75.

Using Equation 12 and the fact that k equals fF_w yields

$$C_{aMAX} = C_w f F_w t_d / V_a \tag{18}$$

One can use typical values for the variables indicated above to obtain

$$C_{aMAX} = C_w(0.75)(500)(0.1)/10^4 = 3.75\text{x}10^{-3}\ C_w \tag{19}$$

The value for C_{aAVG} would be one-half this, or $1.9\text{x}10^{-3}\ C_w$. It is interesting to note that Prichard and Gesell [10] predicted that for a five-minute shower using 75 L of water and with 65% volatilization in a 30,000 L room, the average radon air concentration would be $1.6\text{x}10^{-3}\ C_w$. Similarly, McCone [9] modeled several low molecular-weight organics volatilizing with multiple family use of a bathroom in the early morning hours and calculated typical bathroom air concentrations of $5\text{x}10^{-3}\ C_w$.

Such predicted air concentrations will be highly dependent on a variety of factors, including the nature of the volatilizing chemical, geometry and air exchange between the shower and surrounding room, water temperature, and water flow rate. Nevertheless, these can be assessed to determine the likely range of bathroom air concentrations that can be expected in homes.

It is also of interest to estimate the inhalation exposures in the shower and bathroom, and compare them to the likely ingestion exposures. Inhalation exposure, E_i (mg), can be defined as the product of C_a, the breathing rate, B (L/h), typically 1,000 L/h for an adult, and the exposure time, t.

$$E_i = C_a Bt \tag{20}$$

As an example, one can use this equation to estimate the exposures during a 0.1 h showering time, using the value of C_{aAVG} above of 1.9×10^{-3} C_w. Also as noted above, during a 0.2 h period subsequent to the shower, the decay will not be significant, so that the C_{aAVG} during this period can be taken to be C_{MAX}, namely 3.75×10^{-3} C_w. Thus, one can calculate the E_i for the combined 0.1 h shower and 0.2 h subsequent period in the bathroom as the sum of two terms using Equation 20, to give

$$E_i = [C_{aAVG}Bt]_{shower} + [C_{aAVG}Bt]_{decay} \tag{21}$$

Inserting the appropriate values, one obtains

$$E_i = 1.875\times10^{-3}\ C_w(1000)(0.1) + 3.75\times10^{-3}\ C_w(1000)(0.2) \tag{22}$$

Thus, E_i has the value $0.94C_w$, where the units of C_w are mass/L.

This is the inhalation exposure in the bathroom during the shower and subsequent to it while the bather remains in the bathroom, and is approximately equivalent to the exposure that would occur from ingesting one liter of the water. However, several occupants of a home may take a shower during a period when the volatile chemical air concentration in a bathroom has not decayed and builds up to levels higher than one would predict for a single bather. In that instance, the exposures could be substantially higher than would be predicted by the above relationship.

Similarly, we have used a simple predictive equation, based on a one-compartment indoor-air model, to describe the range of average indoor-air concentrations that are likely to be encountered from a chemical volatilizing at an average rate of 50% from all water uses, as discussed above to be a typical value for radon. The relationship we have obtained for the expected range of indoor-air concentrations is [7]

$$C_a = (0.1 \text{ to } 5)\times10^{-4}\ C_w \qquad (23)$$

where C_a is the average indoor-air concentration (mg/L), generated by the corresponding average water concentration, C_w (mg/L). Thus, for example, a water concentration of 1 mg/L would be expected to generate between 1×10^{-5} to 5×10^{-4} mg/L average air concentration in the home. This, of course, does not address the time and space variations that will be encountered throughout the day in the home. It is interesting to note that

Nazaroff et al. [13] have similarly made estimates of the likely indoor-air concentrations of radon for U.S. homes by the water volatilization route. The geometric mean in their factor applicable to Equation 23 is 0.65×10^{-4}, within our range of predicted values. Also, their range of one standard deviation around the mean corresponds to the following equation

$$C_a = (0.23 \text{ to } 1.87)\times10^{-4}\ C_w \qquad (24)$$

also within our predicted range. McKone [9] has similarly estimated household air concentration for several volatilizing chemicals, predicting an average C_a ranging from 2×10^{-5} to 1.2×10^{-4} mg/L in air for a C_w of 1 mg/L in water, also within the range of that predicted by Equation 23.

One can use these air concentration predictions to estimate the likely inhalation exposures, E_i, for an adult during a 24-hour residence period in a house. Combining Equations 20 and 23 one obtains

$$E_i = (0.1 \text{ to } 5)(10^{-4})(1000)(24)\ C_w = (0.2 \text{ to } 10)\ C_w \qquad (25)$$

Since the C_w units here are mass/L, a 1 mg/L water concentration corresponds to a range of inhalation exposures of 0.2 to 10 mg per day, in comparison to 2 mg per day for the ingestion of 2 liters of that water. It should be noted that these inhalation exposure estimates do not include those that would occur at the point of water use, such as during showering. As discussed above, the latter exposures can be comparable to those from direct ingestion.

There is a remarkable consistency in the above range of likely predicted average indoor-air concentrations from the totality of indoor water sources. Nevertheless, there are a number of factors to be considered in refining these estimates and developing a useful and simple predictive relationship that can be applied by those responsible for exposure assessments in specific situations. They can be categorized as follows:

a) chemical characteristics that affect the rate and extent of volatilization, including soap and detergent use

b) water use factors that affect the "source strength" and its time and location variability

c) chemical characteristics that influence the behavior and interactions of the volatilized chemicals with "sinks", typically high surface area materials in the home; also the specific nature, amounts, and locations of these sinks

d) house structure and indoor-air flow regimes that transport the volatilized chemicals throughout the home

e) personal behavior and home occupancy factors that determine an individual's exposure.

The simple indoor-air models mentioned above generally are not sufficiently specific to address all the above factors, although they can and have been evaluated for some indoor-air pollution sources other than those from water [26].

The potential interactions between surfaces in homes and organic vapors released from water into indoor air have not been studied and need to be evaluated. For some chemicals it may be appropriate to incorporate these interactions into the volatilization, indoor-air exposure model. One study of the interaction of volatile organic chemicals with materials used in the home examined three surfaces [27]: plywood, nylon carpeting, and wool carpeting. The study focused on twenty volatile organic chemicals, including alkanes, aromatics, alcohols, esters, ketones, aldehydes, terpenes, and chlorinated hydrocarbons. They showed clear interactions between the gaseous organic chemicals and the surfaces. For example, in one experiment wool carpeting became essentially saturated with lindane within about one day.

In order to determine the role of such "sink" interactions there are three broad questions that need to be addressed:

1) Which classes of organic/surface systems demonstrate significant sorption effects?

2) What are the appropriate equilibrium and kinetic models for the sorption process for the organic/surface systems of interest?

3) How can this equilibrium and kinetic information be incorporated into a water-volatilization, indoor-air quality model?

Summary and Conclusions

VOC's have the potential for causing substantial human exposures from indoor uses of contaminated water by non-ingestion routes, namely inhalation following volatilization from water, as well as by skin contact. The latter exposures have been estimated to be comparable to those from direct ingestion of water, although published research in this area is scanty.

Measurements in homes have shown that VOC's can be detected in indoor air following the use of contaminated water. Scaled-down and full-size laboratory bath and shower studies for such VOC's as chloroform and trichloroethylene have shown that a variety of factors can affect the extent of volatilization, found to be typically in the range of 50 to 90%. These include the nature of the volatilizing chemical, water temperature, air and water flow rates, and nature of the water use (e.g., bath versus shower).

The Henry's law equilibrium constants, H, predict that even chemicals with low vapor pressures may be expected to volatilize substantially, provided their water solubilities are also low. Thus, so-called semi-volatile organic chemicals have the potential to volatilize and cause inhalation exposures. Also, chemicals with varying H values may nevertheless volatilize at comparable rates.

Modeling and estimates of inhalation exposures to VOC's indicate that for the bather these exposures during and directly after a shower can be comparable to that from direct ingestion of the contaminated water. Also, when all water uses are considered, the inhalation exposures to all inhabitants of a home may be substantially larger than that from direct ingestion, even without considering the inhalation exposures at the point of water use. However, additional research is required to more specifically and precisely quantify these exposures to encompass the full range of home characteristics, as well as personal water uses and occupancy factors.

Because the non-ingestion exposures to VOC's in indoor water uses are likely to be comparable to or greater than those from direct ingestion, it would be prudent to consider this in establishing regulatory limits in drinking water, as well as the need to restrict all indoor water uses when it is judged that there is a significant health risk from the direct ingestion of a contaminated water.

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Appendix B: Assumptions and Uncertainties

- Equation (4) does not account for the concentration of the chemical in the air remaining from previous showers taken by other members of the family.

- The use of Equation (4) also assumes that $(F_a/V)t$, where F_a is the air flow rate, is small compared to unity, which implies that the relationship between concentration in air and time is linear.

- Equation (4) also assumes that C_a/H during the course of the shower is small compared to C_w; which implies that the volatilization rate in the shower is constant.

- The use of Equation (6) assumes that $tF_a/2V_a$ is small compared to unity so that the concentration during the decay period after the shower, C_{AVE2}, can be approximated by C_{MAX}.

- The exchange between the air in the shower chamber and that in the bathroom is so rapid that the combined volume of these two compartments can be treated as a single chamber with a single concentration of volatilized chemical.

- Equation (4) does not account for the exchange rate that occurs when an exhaust fan is turned on. Modeling results using the Model for Analysis of Volatiles and Residential Indoor-air Quality (MAVRIQ) indicate that exposure is reduced by 20 % if exhaust fan is used.

- The range of volatilization fraction in Table 1 is based on experiments conducted with trichloroethylene, chloroform and dibromochloropropane. The relationship between these volatilization rates, Henry's Law Constant and molecular weight is not known yet. Summarized below are the experimental results for these three chemicals under approximately the same conditions.

Chemical	T (°C)	H (unitless)	% Volatilized
Trichloroethylene	46	1.14	81.8
Chloroform	42	0.35	56
Dibromochlorpropane	42	0.03	22.8

- Equation (8) treats the whole house as one compartment model.

S

APPENDIX S

CITY OF WOODSTOCK RESOLUTIONS AND ORDINANCES

RESOLUTION NO. 635

1- Recorder
1- MTC
1- File

RESOLUTION CREATING A COVENANT RUNNING WITH THE LAND ON THE MUNICIPAL LANDFILL OF THE CITY OF WOODSTOCK, McHENRY COUNTY, ILLINOIS

WHEREAS, the CITY OF WOODSTOCK, is the owner of the tract of land upon which the now closed WOODSTOCK MUNICIPAL LANDFILL is located; and,

WHEREAS, the CITY OF WOODSTOCK has been designated as a potentially responsible party (PRP) by the United States Environmental Protection Agency (U.S.E.P.A.) pursuant to the provisions of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and is now participating in a remedial investigation/feasibility study (RI/FS) pursuant to an administrative order by consent effective October 14, 1989; and,

WHEREAS, it is necessary that the CITY OF WOODSTOCK, McHenry County, Illinois finally determine the use or uses to which said real estate may be used in the future and forever prohibit certain activities on said real estate:

> The Northwest Quarter of the Southeast Quarter of Section 17, and the Southwest Quarter of the Northeast Quarter of Section 17, (excepting and reserving therefrom that part thereof bounded and described as follows to-wit: Beginning at a post at the Northwest corner of the last described forty; thence East 8 chains 17 links to a post; thence South 74 1/4 degrees West 8 chains and 48 links to a post; thence North 2 chains and 50 links to the place of beginning. ALSO: A part of the Northwest Quarter of the Northeast Quarter of said Section 17, bounded and described as follows: Beginning at the Southeast Corner of said last above described forty; thence West 11 chains and 77 links; thence North 74 1/4 degrees East 12 chains and 22 links to a post; thence South 3 chains and 60 links to the place of beginning, all in Township 44 North, Range 7, East of the Third Principal Meridian in McHenry County, Illinois.

Return to: City of Woodstock P.O. Box 14, Woodstock, IL 60098

NOW THEREFORE BE IT RESOLVED by the City Council of the CITY OF WOODSTOCK, McHenry County, Illinois, that there is hereby created the following restriction:

91-41-1210

No well of any kind, nature or description, other than wells approved by or required by Environmental Regulating Agencies, including U.S.E.P.A., and Illinois E.P.A. as part of any site remediation or monitoring work, and no residential use or structure of any kind shall be located on or shall be built or constructed in or on the following described real estate:

The Northwest Quarter of the Southeast Quarter of Section 17, and the Southwest Quarter of the Northeast Quarter of Section 17, (excepting and reserving therefrom that part thereof bounded and described as follows to-wit: Beginning at a post at the Northwest corner of the last described forty; thence East 8 chains 17 links to a post; thence South 74 1/4 degrees West 8 chains and 48 links to a post; thence North 2 chains and 50 links to the place of beginning. ALSO: A part of the Northwest Quarter of the Northeast Quarter of said Section 17, bounded and described as follows: Beginning at the Southeast Corner of said last above described forty; thence West 11 chains and 77 links; thence North 74 1/4 degrees East 12 chains and 22 links to a post; thence South 3 chains and 60 links to the place of beginning, all in Township 44 North, Range 7, East of the Third Principal Meridian in McHenry County, Illinois.

BE IT FURTHER RESOLVED that this restriction shall be deemed a permanent covenant running with the land which shall forever bind the CITY OF WOODSTOCK, McHenry County, Illinois, and it successors and assigns in perpetuity.

BE IT FURTHER RESOLVED that this resolution is a permanent resolution of public policy of the CITY OF WOODSTOCK and may not be amended or repealed by any subsequent City Council.

91R 36255

BE IT FURTHER RESOLVED that this resolution be spread at length upon the minutes of the meeting of this City Council and recorded in the Office of the Recorder of Deeds, McHenry County, Illinois.

ADOPTED BY THE CITY COUNCIL OF THE CITY OF WOODSTOCK, McHENRY COUNTY, ILLINOIS THIS 17 DAY OF SEPTEMBER, 1991.

AYES: 5
NAYS: 0
ABSENT: 0

MAYOR

Adopted: 9-17-91
Approved: 9-17-91

ATTEST:

CITY CLERK

APPROVED AS TO FORM:

CITY ATTORNEY

Document Prepared by:
Michael T. Caldwell
CALDWELL, BERNER AND CALDWELL
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Woodstock, Illinois 60098
Telephone: (815) 338-3300

91R 036255

91 SEP 23 PM 2:26

McHENRY COUNTY RECORDER
PHYLLIS K. WALTERS

91-41-1212

ORDINANCE NUMBER 2265

AN ORDINANCE AMENDING THE ZONING REGULATIONS OF THE CITY OF WOODSTOCK, ILLINOIS

Be it Ordained by the Mayor and City Council of the City of Woodstock, McHenry County, Illinois, as follows:

Section One. That Section 3.15 of the Woodstock Zoning Ordinance, adopted as Ordinance Number 1520 (as amended) is deleted and the following adopted in lieu thereof:

3.15 DEVELOPMENT REGULATIONS

The following regulations shall apply to any acreage, lot, or lots proposed to be rezoned, developed as a Planned Development, or annexed to the City of Woodstock.

1. If the acreage, lot or lots is two (2) acres in size or larger and 50 percent or more of it is comprised of flood plain areas (as defined in the ordinances of the City of Woodstock); or 50 percent or more of it is comprised of wetland areas (as determined by the McHenry County Soil and Water Conservation District using the Federal Manual for Identifying and Delineating Jurisdictional Wetlands). or if the wetland on the property in question is part of an overall wetland that is one (1) acre in size or larger, then any proposal for its rezoning, development, or annexation must be submitted and reviewed as a Planned Development. The boundaries of any flood plain or wetland shall be:

a. indicated on the Conceptual Plan, Preliminary Plan, and Final Plat of Planned Development;

b. identified and marked on the development site;

The boundary of a wetland site shall be abutted by a buffer strip having a minimum width of 25 feet extending outward from the identified wetland area. The buffer strip shall be left and maintained in native vegetation where practical, unless otherwise approved with the Final Plat of Planned Development.

If a proposed Planned Development involves encroachment into a flood plain area, the extent of encroachment must be indicated on the Conceptual Plan, Preliminary Plan, and Final Plat of Planned Development. Compensatory flood plain storage shall be provided. Engineering plans required as part of the Plan Development process shall include specifications providing for such storage. If a proposed Planned Development involves improvements which are intended to encroach onto or result in the filling of a wetland area, then:

a. No net loss of wetland area or functional value will be permitted;

b. Wetland mitigation or relocation on the site shall provide for a 1 to 1.5 (filled/removed wetland to restored/recreated wetland) mitigation ratio, and wetland mitigation will be permitted only if the site is otherwise unable to be developed and is for all practical purposes unusable. Off-site mitigation may occur only if on-site mitigation is not practical and only within the same watershed as the wetland being mitigated, and with a permanent preservation easement approved and recorded for the off-site portion of the mitigated area.

c. U.S. Army Corps of Engineers review and approval shall be obtained for all wetland mitigation and/or fill activity, unless such approval is deemed by the Corps of Engineers to be unnecessary. If the Corps of Engineers determines that such approval is unnecessary, then detailed plans for mitigation and fill activity shall be submitted to the City of Woodstock for its review. The City of Woodstock reserves the right to impose requirements in addition to any permit requirements of the U. S. Army Corps of Engineers, as part of the Planned Development Special Use.

2. If the land contains flood plain having an area of at least one (1) acre, but comprising less than 50 percent of the site being rezoned, developed, or annexed, or if the land contains wetlands having an area of at least one acre, and if the wetland is not part of any overall wetland having an area of one (1) acre or greater, then any proposal for its rezoning or development shall indicate whether encroachment into such flood plain and/or wetland is proposed. If such encroachment is indicated, then detailed plans or similar documentation indicating the extent and type of such encroachment shall be submitted when a formal rezoning petition or development proposal is submitted to the City staff, and shall indicate that:

a. compensatory flood plain storage is provided;

b. that the proposed encroachment cannot be avoided and that without such encroachment the land is for all practical purposes unusable.

c. the proposed encroachment into a wetland area has been submitted for review to the U.S. Army Corps of Engineers and that approval for mitigation and/or fill activity has been granted or deemed to be unnecessary by the Corps of Engineers. The City of Woodstock reserves the right to impose requirements in addition to any permit requirements of the U. S. Army Corps of Engineers, as part of the Planned Development Special Use.

3. Regardless of the size of a land parcel and regardless of the wetland area on it, if a wetland extends beyond the boundary of a development site, then a map delineating the entire wetland site, including the area of such extension, shall be required.

4. If 50 percent or more of the land is composed of soils with severe limitations for urban development, (based on ability to accommodate dwellings with and without basements, ability to support roads and streets, and impact of hydric characteristics), as determined by the U. S. Department of Agriculture Soil Conservation Service Soil Interpretations Records, then any proposed rezoning or development must be preceded by soil borings and an accompanying soil engineering analysis indicating those portions of the land which can accommodate structural improvements. This information must be submitted when an initial rezoning petition or development proposal is formally submitted.

<u>Section Two</u>. That Section 5.4.13(6), pertaining to Conceptual Plan submittal requirements, of the Woodstock Zoning Ordinance, adopted as Ordinance Number 1520 (as amended) is deleted and the following adopted in lieu thereof:

6. Environment

A preliminary statement identifying existing natural and environmental resources, and the methods to be used to protect the physical amenities of the site must be provided, and shall include information on the following:

a. One foot topographic contour lines extending beyond the development boundaries an adequate distance to show the existing elevations and terrain of the adjoining properties.

b. Flood plains, wetlands, and surface hydrology. Wetland boundaries shall be shown on the drawing of the Planned Development. The floodplain and wetland area shall be identified and a preliminary report addressing the type and quality of wetlands shall be provided, and shall be accompanied by a statement of intent regarding proposed preservation, elimination, or mitigation. If the wetlands extend beyond the Planned Development boundary, a map shall be provided which shows the entire wetlands area.

c. Vegetation, areas of natural coverage, and wooded areas, including a survey of trees having a diameter measured at breast height (DBH) of six (6) inches or greater, and a preliminary report showing the trees to be removed for the development project

d. Soils and subsurface conditions and unique geological features, including the designation of those soils with severe limitations for urban development (based on ability to accommodate dwellings with and without basements, ability to support roads and streets, and impact of hydric features), as determined by the U. S. Department of Agriculture Soil Conservation Service Soil Interpretations Records.

<u>Section Three</u>. That Sections 5.4.14(1)f and g, pertaining to Preliminary Plan submittals, of the Woodstock Zoning Ordinance, adopted as Ordinance Number 1520, be deleted and the following adopted in lieu thereof.

f. Soil Conditions on the Tract - Locations and results of tests made to generally ascertain subsurface soil, rock, and ground water conditions, and depth to ground water. For those areas comprised of soils with severe limitations for urban development, as identified in Section 5.4.3.(6)d of this Ordinance, soil borings must be conducted and an analysis provided indicating those portions of the site which have the ability to serve as building sites. Areas which are determined to be unsuitable as building sites or roadway construction shall be so identified. If corrective measures are proposed to eliminate soils with severe limitations for urban development, then plans for the implementation of such measures shall be included as part of required engineering plans and submittals.

g. Other Conditions on the Tract -

(1) Water courses, flood plains, wetlands, marshes. Detailed floodplain boundaries shall be shown on the preliminary plan of Planned Development. Wetland boundaries as determined by field obseravtions and measurements shall be shown on the preliminary plan of Planned Development and shall be identified and marked on the Planned Development site. A wetlands inventory consisting of a detailed scientific report which assesses the quality of the wetland area and more accurately

defines its boundaries, shall be submitted in order to determine the primary function and quality of the wetland site. The inventory shall be accompanied by a preservation and/or mitigation plan which provides details regarding the developer's intent and methods for such preservation or mitigation.

(2) Wooded areas, including a survey of trees having a diameter measured at breast height (DBH) of six (6) inches or greater. Indication shall be made of those trees which are intended to be preserved, eliminated, or relocated on the site, as well as those trees which are of poor quality and health.

Section Four. That Section 5.4.15(1)c, pertaining to Final Plat submittals, of the Woodstock Zoning Ordinance, adopted as Ordinance Number 1520 (as amended), is deleted and the following adopted in lieu thereof:

c. An accurate legal description of each separate unsubdivided use area, including common open space, flood plains, and wetland area boundaries. Total wetland area, as well as total development site area, shall be stated. Wetland areas shall be identified and marked on the Planned Development site. Detailed plans and specifications for wetland preservation or mitigation, including cost estimates and U. S. Army Corps of Engineers' approval where applicable, shall be submitted. The location of all trees to be preserved, as well as the legal description and location of easements designating trees to be preserved, shall be provided. Those areas which cannot serve as building sites shall be identified on the plat.

Section Five. That this ordinance shall be known as Ordinance Number 2265 and shall be in full force and effect thirty (30) days after its passage, approval, and publication as provided by law.

Section Six. Any ordinances or parts thereof or any regulations in conflict with this ordinance are hereby repealed.

PASSED and APPROVED by the City Council of the City of Woodstock, McHenry County, Illinois, this 16 day of October, 1990.

Jim D. Shoemaker
Mayor

Passed: 10-16-90
Approved: 10-16-90

Attest:
Nancy Irwin
City Clerk

Approved as to Form:
Richard S. Caldwell
City Attorney

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APPENDIX T

AGENCY RESPONSES REGARDING ENDANGERED AND THREATENED SPECIES

APPENDIX U

BIOLOGICAL EFFECTS RANGES
FOR SELECTED METALS

APPENDIX V

TOXICOLOGY PROFILES FOR CHEMICALS OF POTENTIAL CONCERN

V

Table 16. Effects range-low and effects range-median values for nickel and 18 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
21	Massachusetts Bay benthos COA
28	Puget Sound, Washington, AET - Microtox™
30	ER-L
30	Commencement Bay, Washington, bioassay COA
31	Los Angeles Harbor, California, bioassay COA
33	Massachusetts Bay benthos COA
39	Puget Sound, Washington, AET - oyster
40	Little Grizzly Creek, California, bioassay COA
41	Commencement Bay, Washington bioassay COA
49	Puget Sound, Washington, AET - benthic
50	ER-M
52	Black Rock Harbor, Connecticut, bioassay COA
88	Lake Union, Washington, bioassay COA
94	Palos Verdes Shelf, California, benthos COA
97	Baltimore Harbor, Maryland, bioassay COA
100	Keweenaw River, Michigan, bioassay COA
109	Keweenaw River, Michigan, bioassay COA
110	Sheboygan River, Wisconsin, bioassay COA
150	Torch Lake, Michigan, bioassay COA
350	Phillips Chain of Lakes, Wisconsin, bioassay COA

Table 20. Effects range-low and effects range-median values for zinc and 46 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
51	Sublethal SSB with *R. abronius*
59 - 124	Sublethal SSB with *P. affinis*
98	Massachusetts Bay, Massachusetts benthos COA
117	Massachusetts Bay, Massachusetts benthos COA
120	ER-L
121	Trinity River, Texas bioassays COA
127	Waukegan Harbor, Illinois bioassays COA
130	San Francisco Bay, California AET
154	Keweenaw Waterway, Michigan bioassays COA
168	Keweenaw Waterway, Michigan bioassays COA
169	Feral Fraser River *M. balthica* absent COA
172	*M. balthica* avoidance bioassay COA
172	San Francisco Bay, California bioassays COA
182	Southern California arthropod abundance COA
185	Commencement Bay, Washington bioassays COA
188	Sublethal SSB with *R. abronius*
195	Puget Sound, Washington bioassays COA
197	Southern California species richness COA
205	San Francisco Bay, California bioassays COA
211	Commencement Bay, Washington bioassays COA
223	Los Angeles Harbor, California bioassays COA
230	San Francisco Bay, California AET
230	Southern California echinoderm abundance COA
260	Puget Sound, Washington AET - benthic
267	Little Grizzly Creek, California bioassays COA
270	ER-M
276	SSB with *R. abronius* LC50
290	Sheboygan River, Wisconsin bioassays COA
310	Torch Lake, Michigan bioassays COA
320	Lake Union, Washington bioassays COA
327	DuPage River, Illinois species richness COA
334	Black Rock Harbor, Connecticut bioassays COA
348	Southern California bioassays COA
387	Commencement Bay, Washington bioassays COA
410	Puget Sound, Washington AET - benthic
449	Hudson-Raritan Bay, New York bioassays COA
570	Phillips Chain of Lakes, Wisconsin bioassays COA
613	SSB with *R. abronius*
707	Puget Sound, Washington bioassays COA
739	Palos Verdes Shelf, California "major degradation" COA
760	EP marine chronic threshold @ 4% TOC
870	Puget Sound, Washington AET - amphipod
941	Commencement Bay, Washington bioassays COA
960	Puget Sound, Washington AET - amphipod
1600	Puget Sound, Washington AET - oyster
1600	Puget Sound, Washington AET - Microtox™
1804	Baltimore Harbor, Maryland bioassays COA
2240	EP marine acute threshold @ 4% TOC

Table 14. Effects range-low and effects range-median values for mercury and 30 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
0.032	EP Chronic Marine @4% TOC
0.08	Waukegan Harbor, Illinois bioassay COA
0.15	ER-L
0.15	Los Angeles Harbor, California bioassay COA
0.17	Lake Union, Washington bioassay COA
0.18	*M. balthica* burrowing bioassay COA
0.29	Torch Lake, Michigan bioassay COA
0.41	Puget Sound, Washington bioassay AET - Microtox™
0.42	Fraser River, B.C., Canada *M. balthica* bioassay COA
0.48	*M. balthica* avoidance bioassay COA
0.59	Puget Sound, Washington AET - oyster
0.6	EP acute marine @4% TOC
0.88	Puget Sound, Washington AET - benthic
0.9	San Francisco Bay, California bioassay COA
0.9	Cubatao River, Brazil bioassay COA
0.96	San Francisco Bay, California bioassay COA
1.3	ER-M
1.3	San Francisco Bay, California AET
1.38	Puget Sound, Washington bioassay COA
1.5	San Francisco Bay, California AET
1.5	Little Grizzly Creek, California bioassay COA
1.6	Baltimore Harbor, Maryland bioassay COA
1.6	DuPage River, Illinois benthos COA
2.1	Puget Sound, Washington AET - amphipod
2.1	Puget Sound, Washington AET - benthic
2.15-3.35	SSB with *Pontoporeia*
3.5	Commencement Bay, Washington bioassay COA
5.04	Puget Sound, Washington bioassay COA
8.9	Hudson-Raritan Bay, New York bioassay COA
9.4	Phillips Chain of Lakes, Wisconsin bioassay COA
11.2	Commencement Bay, Washington bioassay COA
13.1	SSB with *R. abronius*

Other Major and Trace Elements

Data with which measures of biological effects could be related to the concentrations of aluminum, iron, manganese, silicon, thallium, and selenium were not found. Therefore, no ER-L or ER-M values were determined for these analytes that are quantified in sediments by the NS&T Program.

Table 12. Effects range-low and effects range-median values for lead and 47 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
27	Keweenaw Waterway, Michigan bioassay COA
29.0	Keweenaw Waterway, Michigan bioassay COA
30.6	Kishwaukee River Illinois, benthos COA
32.0	*M. balthica* burrowing ET50 COA
35.0	Norway benthos COA
35.0	ER-L
41.3	Los Angeles Harbor, California bioassay COA
42.1	San Francisco Bay, California bioassay COA
42.4	Massachusetts Bay, Massachusetts benthos COA
46.7	Massachusetts Bay, Massachusetts benthos COA
47.8	Southern California arthropods COA
≤50.0	San Francisco, California, triad minimum effects COA
51.0	Southern California species richness COA
53.7	Trinity River, Texas bioassay COA
58.9	San Francisco Bay, California bioassay COA
>60.0	FWPCA Classification: benthos absent COA
63.4	San Francisco Bay, California bioassay COA
64.4	Southern California echinoderms COA
73.1	Southern California bioassay COA
74.0	*M balthica* bioassay avoidance COA
81.7	Fraser River B.C., Canada benthos COA
89.6	Black Rock Harbor, Connecticut bioassay COA
95.7	San Francisco Bay, California bioassay COA
104.5	San Francisco Bay, California bioassay COA
110.0	ER-M
110.0	Torch Lake, Michigan bioassay COA
113.1	Commencement Bay, Washington bioassay COA
120.0	San Francisco Bay, California AET
≥130.0	San Francisco Bay, California triad significant effects COA
132.0	EP chronic marine @4% TOC
136.6	Puget Sound, Washington bioassay COA
140.0	San Francisco Bay, California AET
143.7	DuPage River, Illinois benthos COA
160.0	Phillips Chain of Lakes, Wisconsin bioassay COA
170.8	Commencement Bay, Washington bioassay COA
253.0	Sheboygan River, Wisconsin bioassay COA
300.0	Puget Sound, Washington AET - benthic
300.0	Lake Union, Washington bioassay COA
312.3	Palos Verdes Shelf, California benthos COA
320.9	Hudson-Raritan Bay, New York bioassay COA
450.0	Puget Sound, Washington AET - benthic
512.0	Baltimore Harbor, Maryland bioassay COA
530.0	Puget Sound, Washington AET - Microtox™
570.1	Commencement Bay, Washington bioassay COA
660.0	Puget Sound, Washington AET - amphipod

Table 4. Effects range–low and efects range–median values for arsenic and 16 concentrations used to determine these values arranged in ascending order.

Concentration (ppm)	End Point
22.1	San Francisco Bay, California bioassay COA
33.0	ER-L
33.0	EP chronic @4% TOC
50.7	San Francisco Bay, California bioassay COA
54.0	San Francisco Bay, California AET
57.0	Puget Sound, Washington AET - benthic
58.7	Commencement Bay, Washington bioassay COA
63.2	Commencement Bay, Washington bioassay COA
64.0	EP Acute @4% TOC
85.0	ER-M
85.0	Puget Sound, Washington AET - benthic
91.9	Baltimore Harbor, Maryland bioassay COA
93.0	Puget Sound, Washington AET - amphipod
689.9	Commencement Bay, Washington bioassay COA
700.0	Puget Sound, Washington AET - oyster
700.0	Puget Sound, Washington AET - Microtox™
1005.0	Puget Sound, Washington bioassay COA
2257.1	Commencement Bay, Washington bioassay COA

Table 10. Effects range-low and effects range-median values for copper and 51 concentrations used to determine these values arranged in ascending order.

Concentrations (ppm)	End Point
15.0	Massachusetts Bay benthos COA
17.8	Sublethal SSB with *Macoma*
19.5	Waukegan Waterway, Illinois bioassay COA
45.4	Kishwaukee River, Illinois benthos COA
67.0	*M. balthica* burrowing ET50 COA
68.2	San Francisco Bay, California bioassay COA
68.4	Trinity River, Texas bioassay COA
70.0	ER-L
76.0	San Francisco Bay, California bioassay COA
84.6	San Francisco Bay, California bioassay COA
87.7	San Francisco Bay, California bioassay COA
96.7	Southern California echinoderms COA
106.3	Commencement Bay, Washington bioassay COA
110.0	San Francisco Bay, California AET
117.8	Commencement Bay, Washington bioassay COA
134.6	Fraser River, B.C. benthos - *M. balthica* COA
136.0	EP chronic marine threshold
138.0	Puget Sound, Washington bioassay COA
145.0	Sheboygan River, Wisconsin bioassay COA
147.0	Los Angeles Harbor, California bioassay COA
150.0	Fraser River, B.C bioassay COA
156.0	Lake Union, Washington bioassay COA
180.0	San Francisco Bay, California AET
181.3	Southern California bioassay COA
200.0	Norway benthos COA
216.0	EP acute marine threshold
310.0	Puget Sound, Washington AET - benthic
390.0	ER-M
390.0	Puget Sound, Washington AET - oyster
390.0	Puget Sound, Washington AET - Microtox™
453.0	Hudson-Raritan Bay, New york bioassay COA
530.0	Puget Sound, Washington AET - benthic
540.0	Phillips Chain of Lakes, Wisconsin bioassay COA
589.0	Keweenaw Waterway, Michigan benthos COA
592.0	Palos Verdes Shelf, California, bioassay COA
592.0	Palos Verdes Shelf, California benthos COA
612.0	Black Rock Harbor, Connecticut bioassay COA
612.0	Keweenaw Waterway, Michigan bioassay COA
681.0	SSB with *Daphnia*
730.0	Keweenaw Waterway, Michigan bioassay COA
810.0	Puget Sound, Washington AET - amphipod
857.0	SSB with midge
918.0	Commencement Bay, Washington bioassay COA
937.0	SSB with *Daphnia*
964.0	SSB with amphipod
1071.0	Baltimore Harbor, Maryland bioassay COA
1078.0	SSB with amphipod
1260.0	Puget Sound, Washington bioassay COA
1300.0	Puget Sound, Washington AET - amphipod
1374.0	Little Grizzly Creek, California bioassay COA
1800.0	Torch Lake, Michigan bioassay COA
2296.0	SSB with midge
2820.0	Commencement Bay, Washington bioassay COA

VINYL CHLORIDE

Uses

Vinyl chloride is the most important vinyl monomer and was the 19th highest-volume chemical produced in the United States in 1985. The compound is used to produce polyvinyl chloride and copolymers, and adhesives for plastics.

Effects from Long-Term Exposure

Chronic studies in common laboratory animal species have identified a number of toxic effects of vinyl chloride exposure including: hepatomegaly, decreased adrenal weight, pathology of the kidney, splenomegaly, hematological and biochemical changes in the blood, and hyperplasia of lung epithelium. Other toxic effects attributed to vinyl chloride exposure in humans include sclerdoerma, acro-osteolysis and Raynaud's syndrome.

Two studies conducted in rodents indicate that vinyl chloride is not a teratogen, although some fetotoxic effects were observed.

Carcinogenic Potential

Vinyl chloride is a human carcinogen, having been identified as the causative agent in hepatic angiosarcomas in industrial workers. Similar cancers have been produced by vinyl chloride administration to animals. In addition, evidence suggests that cancer of other tissues such as the brain, lung and blood may be attributable to vinyl chloride. The U.S. EPA classifies vinyl chloride as a Group A, human carcinogen.

ZINC

Uses

Zinc is a shining white metal with bluish gray luster which is used in galvanizing iron and other metals. It is also used in automotic parts, electrical fuses, batteries, fungicides, and in nutrition (essential growth element). Zinc salts and organozinc compounds are used in medicine (astringent), preserving wood, textile dying, and as insecticides, laboratory reagants, dietary supplements, feed additives, and ceramic glazes.

Noncancer Effects from Long-Term Exposure

Zinc is an essential element which is needed for the proper function of enzyme systems in the body. In the human, daily intakes must exceed approximately 10 times the recommended daily allowance for the metal (i.e. 15 mg/day) before adverse health effects would be expected. At very high doses of zinc, gastric discomfort has been noted in some exposed individuals

Long-term exposure to high doses of zinc may cause a form of anemia (hypochromic microcytic) caused by lowered copper levels in the body. The anemia may be treated by lowering zinc intake and increasing copper intake.

Long-term inhalation exposure to zinc dose not pose a problem if zinc air concentrations are not high. Based on studies with workers, the National Institute of Occupational Health and Safety (NIOSH) has set a safe air concentration in air (i.e. PEL) to be 15 mg/m^3.

Although it is known that excessive zinc intake can cause reproductive problems, it is well documented that zinc deficiencies will also cause reproductive problems. For this reason, low level environmental exposure to zinc should not result in reproductive problems.

Carcinogenic Potential

In the available literature, no studies were located that linked zinc exposure to increases in the frequency of cancer. There is some evidence that zinc may be a promoter of cancer, but no evidence was found which suggested zinc was an initiator.

VANADIUM

Uses

Vanadium is a silvery-white ductile solid which is used as a target material to produce x-rays, manufacture of alloy steels, vanadium compounds, and catalysts. Vanadium salts and organovanadium compounds are used as battery electrodes, a solid lubricant, as catalysts, for mordanting textiles, and as a colorant in glass.

Noncancer Effects from Long-Term Exposure

No information on the health implications of low level chronic vanadium exposure to humans could be located in the available literature. In animal feeding studies where rats and dogs were administered vanadium pentaoxide at either 10 or 100 parts per million (ppm) in the diet for 2.5 years, no adverse health effects were observed. In fact, rats administered 100 ppm vanadium in their diet weighed more, and lived longer than groups of rats not receiving the vanadium supplements.

Carcinogenic Potential

No information could be located in the available literature on the carcinogenic potential of vanadium in humans. In addition, few animal studies have been conducted to ascertain the carcinogenic potential of vanadium in other animal species. Animal studies to date, have not found vanadium to be carcinogenic, but high quality studies have not yet been done to confirm these earlier findings. For these reasons, the U.S. EPA has classified vanadium as Class D (i.e., unclassified as to its carcinogenicity).

THALLIUM

Uses

Thallium is a bluish-white, lead like solid used to produce a variety of thallium salts, and as an ingredient in mercury alloys, and low-melting glasses. Until the mid 1970s, thallium salts were used widely as rodenticides. Thallium salts are also used in the production of pyrotechnics, infrared radiation transmitters, and artificial gems.

Noncancer Effects from Long-Term Exposure

Thallium is toxic to both humans and other animal species at relatively low dose levels. For this reason, the majority of information on the toxicology of this metal has been gleaned from accidental occupational thallium poisonings. No information on the health implications of low level chronic thallium exposure to humans could be located in the available literature. Animal feeding studies where low doses of thallium salts were administered (i.e., 0.02 mg/kg/day) caused hair loss, and increased serum liver enzyme levels.

Carcinogenic Potential

No information could be located in the available literature on the carcinogenic potential of thallium.

CARCINOGENIC POLYNUCLEAR AROMATIC HYDROCARBONS (PAHS)-BENZO(A)PYRENE

PAHs are a group of aromatic hydrocarbons which are formed naturally as a by-product of incomplete combustion of organic matter. PAHs are not used as a raw material, but are found rather as components of complex mixtures such as coal tars derived from carbonaceous materials (e.g., coal). Certain PAHs are known to be carcinogenic, the most potent and widely studied carcinogenic PAH being benzo(a)pyrene. Within the risk assessment process, as a conservative approach, the carcinogenic potency of benzo(a)pyrene is used to assess the carcinogenic potency of all carcinogenic PAHs. For this reason, the toxicity of only benzo(a)pyrene is described below.

Effects from Long-Term Exposure

There was no information on the toxic effects associated with long-term exposure to benzo(a)pyrene in the available literature. Benzo(a) pyrene being a potent animal carcinogen, research has been limited to this compound's carcinogenic effects.

Information on the teratogenic and reproductive effects of benzo(a)pyrene is limited to studies of oral administration of the compound to pregnant rodents. In rats and mice there is evidence that benzo(a)pyrene is both a reproductive toxicant and teratogen. For example, benzo(a)pyrene at a relatively low dose (50 mg/kg/day) has been associated with drastic reductions in fertility, deformed young, and increased incidence of still births in pregnant rats.

Carcinogenic Potential

Little human data exists on the carcinogenic potential of benzo(a)pyrene in the human. When benzo(a)pyrene was repeatedly applied to the skin of persons over a four month period, there were the formation of benign tumors. Although benign, the tumors were thought to be early stages of neoplastic proliferation.

Many epidemiologic studies of human populations have shown strong associations between human exposure to PAH-containing materials and increased cancer risk. It is assumed that the main carcinogenic initiator may be benzo(a)pyrene in these PAH-containing materials.

In laboratory animals benzo(a)pyrene is clearly a carcinogen. The chemical causes cancer in laboratory animals if administered orally, via inhalation, or applied dermally. Unlike many chemical carcinogens, benzo(a)pyrene is not carcinogenic until it is metabolized in the body by a specific enzyme system. The carcinogenic metabolite has been found to bind to the genetic material in cells (i.e. DNA) and cause the initiation of cancer. Species-to-species variability in the metabolism of benzo(a)pyrene is thought to account for species differences in sensitivity to the carcinogenic effects of the compound.

Because of the weight of evidence, the U.S. EPA has classified benzo(a)pyrene as a probable human carcinogen (B2). Although no slope factor exists for the compound, a unit risk value which relates the probability of contracting cancer per unit exposure (i.e. mg/kg/day) is available from the U.S. EPA.

NICKEL

Uses

Nickel is a malleable silvery metal used in a variety of alloys (e.g., low-alloy steels, stainless steel, and electrical resistance metals) and as an electroplated protective coating for metals. Nickel salts and organo-nickel compounds are used for a variety of purposes including catalysts; as an ingredient in ceramic colors, glazes, paints, and cosmetics; as an antioxidant for synthetic rubbers; and in batteries.

Noncancer Effects from Long-Term Exposure

Information was not available in the available literature on the health effects associated with long-term low level ingestion or inhalation of nickel compounds by humans. Animal studies have shown that drinking water concentrations of 5 parts per million (ppm) nickel caused reduction in the mean body weight of exposed rats. It has also been shown that at this water concentration, nickel is a reproductive toxicant. In multiple generation exposure studies conducted with rats, the rate of neonatal mortality was increased in all generations.

Inhalation of nickel has been associated with pathological changes in the respiratory tract of laboratory animals at high dose levels (i.e., 15 mg/M^3), but no information was found in the available literature on low dose chronic inhalation exposures to nickel.

Carcinogenic Potential

Long-term high dose exposure of humans to nickel refinery dust in the occupational environment has been associated with cancers of the respiratory tract. The majority of carcinomas occurred in the nasal passages, while fewer cases of lung cancer have been detected. The U.S. EPA classifies nickel as a human carcinogen (i.e., Class A).

Currently, little evidence occurs which conclusively suggests that nickel is a carcinogen if ingested. For this reason, the U.S. EPA has classified nickel from this route of exposure as unclassified (i.e., Class D).

PENTACHLOROPHENOL

Uses

Pentachlorophenol, or PCP, is used as a fungicide, bactericide, algicide, herbicide, and wood preservative.

Noncancer Effects from Long-Term Exposure

Pertinent information on the health effects of low level long-term exposure of humans to pentachlorophenol (PCP) could not be located in the available literature. A chronic oral feeding study where rats were fed varying dosages of PCP determined that at the higher dose level (i.e., 30 mg/kg/day) there was reduced body-weight gain, increased specific gravity of the urine, increases in specific enzyme activities, and pigmentation of the liver and kidney. A no-observed-effect-level (NOEL) was determined to be 3 mg/kg/day from this study. Pertinent information on the health effects of PCP inhalation by animals could not be located in the available literature.

Carcinogenic Potential

A single epidemiological study was located in the available literature which tried to assess whether occupational exposure to PCP may cause cancer in humans. This study revealed no increased incidence of cancer in the PCP exposed workers. However, the study had substantial methodological flaws, and too small of a worker population was studied to provide meaningful results.

Two cancer bioassays conducted with mice have associated chronic ingestion of PCP with cancer (i.e., liver and blood). Based on the weight of evidence, the U.S. EPA has classified PCP as a probable human carcinogen (i.e., B2).

MERCURY (INORGANIC)

Uses

Inorganic mercury salts are used for a wide variety of uses which depend in part on the particular salt. Mercury is used in the elemental form in thermometers, barometer, monometers, to name a few. Inorganic salts are used in waterproof paints, antifouling paints, the science of medicine, the tanning industry, and as fungicide and insecticide, as well as photography.

Noncancer Effects from Long-Term Exposure

Human exposure to extremely low air concentrations of mercury (i.e. <0.1 mg/M^3) have been reported to cause mental disturbances, tremors, and gingivitis after long-term exposure. At the lower end of the spectrum, long-term exposure has caused loss of appetite, weight loss and shyness. Chronic exposure to mercury can cause kidney damage which may lead to fibrosis.

Little data could be located in the available literature on the teratogenic or reproductive effects of mercury. No pertinent human data was located. An animal study conducted with rats indicated the metal may be fetotoxic at high dose levels. Many of the pups born to dams inhaling high concentrations of mercury died. Thus, mercury may not be a teratogen, and appears to be fetotoxic at very high levels of exposure.

Carcinogenic Potential

No data could be located in the available literature on the carcinogenic potential of inorganic mercury, but a long-term animal bioassay is underway to determine if mecurial chloride is an animal carcinogen. Currently, inorganic mercury is classified as D- unclassified as a carcinogen by the U.S. EPA.

MANGANESE

Uses

As a metal manganese is used in many ferrous and nonferrous alloys. Salts of manganese are used as varnish and oil driers, antiknock agents in gasoline, as catalysts, as food additives, and as a dietary supplement.

Noncancer Effects from Long-Term Exposure

Manganese is a essential trace nutrient in the human diet. The National Research Council (NRC) has determined a safe level of manganese ingestion to be 2-5 mg/day. Manganese ingested orally is one of the least toxic trace metals. At high concentrations in drinking water 14 to 28 mg/L, manganese can cause lethargy, increased muscle tone, tremors, and mental disturbances. The human body efficiently regulates manganese, therefore unless the dose of manganese becomes excessive, the body can regulate a constant blood serum concentration of manganese.

Inhalation exposure to manganese in the occupational environment has been associated with lung and central nervous system effects for decades. Such effects included pneumonia and mental disturbances.

Carcinogenic Potential

No appropriate information could be located in the available literature on the carcinogenic potential of manganese in humans. Based on negative results in animal studies and weak results in only a small proportion of the mutation bioassays reviewed, manganese does not appear to be a carcinogenic. The metal is currently not classified by the U.S. EPA as a carcinogen (i.e., class D).

LEAD

Uses

Lead has found many uses throughout history. Lead is used as solder, as shot in guns, in batteries, and in the production of tetraethyllead which is used as a gasoline additive. It is used widely as a radiation shielding material.

Noncancer Effects From Long-Term Exposure

In general, the most sensitive system to long term lead exposure is the hematopoietic system. Lead inhibits two key enzymes in the heme synthesis pathway. At high levels, heme synthesis is depressed to the extent that anemia occurs. At high levels of chronic lead exposure, the nervous system, kidneys, and GI tract may also be affected.

Mental deterioration, hyperkinetic or aggressive behavior, sleeping disorders, vomiting have all been associated with chronic lead exposure. There is evidence that various types of neural dysfunction, resulting in permanent learning disabilities, can exist in apparently asymptomatic children. Decreased nerve conduction velocities have been documented in children and adults due to lead exposure. Children are especially sensitive to low-level exposure to lead.

There is little evidence that relatively high prenatal exposure to lead decreases the reproductive capability of women. Lead seems to have detrimental effects on the male reproductive system, however, producing gonadal impairment. Recently, there has been evidence indicating that lead has detrimental effects on the developing human fetus.

Carcinogenic potential

Four epidemiology studies which have been conducted on occupational cohorts exposed to lead have not conclusively linked lead exposure with an increased incidence of cancer. Some studies have found a positive association between lead exposure and cancer while others have not. In general, the studies lack quantitative exposure information, and the sites of cancer (i.e., liver or kidney) are not consistent from study to study. The studies did not account for other known exposures to carcinogens (i.e. arsenic).

Although there is not sufficient evidence to causally link lead exposure and cancer in the human, a number of animal studies have shown associations between lead exposure and renal cancer. Lead is classified as a B2; probable human carcinogen.

Supporting data indicates that lead is mutagenic. Forms of lead have induced cell transformation in hamster embryo cells, as well as enhanced the incidence of simian adenovirus induction. Lead has been found to induce chromosomal aberrations both in-vivo and in-vitro.

CHROMIUM

Uses

Chromium's uses differ depending upon the form of the metal (i.e., elemental state, inorganic salt, organometalic complex). Elemental chromium is used extensively in alloys and as a plating element on metal and plastic substrates for corrosion resistance, and in stainless steels.

Noncancer Effects from Long-Term Exposure

The toxicity of chromium varies greatly between the hexavalent (more toxic) and trivalent (essential nutrient) forms of the metal. Effects summarized are for hexavalent chromium.

Dermal contact with chromium compounds may cause contact dermatitis in humans. This usually occurs at relatively high concentrations of chromium in the medium contacted (e.g., water). Limited information is available on the effects of ingested hexavalent chromium in humans. Clinical observations have indicated that ingestion of 1 mg Cr/L in drinking water for 3 years did not cause any observable effects in humans. Oral ingestion of hexavalent chromium above 25 mg/L in animals has been associated with increased water consumption, but no pathological symptoms.

Carcinogenic Potential

Based on occupational exposure studies, chromium exposure (i.e., both trivalent and hexavalent forms) has been found to cause cancer in humans. Inhalation of chromium is associated with an increased incidence of lung cancer in exposed populations. Trivalent chromium has not been found to be carcinogenic by any route in animal studies, indicating that hexavalent chromium is the causative agent in human studies. Hexavalent chromium has been found to be carcinogenic in animal bioassays and mutation bioassays. Based on the weight of evidence, hexavalent chromium has been classified as a human carcinogen (i.e., A) by the U.S. EPA.

1,4-DICHLOROBENZENE

Uses

1,4-Dichlorobenzene is used as a moth repellant (i.e., moth balls), general insecticide, germicide, space deodorant, and soil fumigant.

Noncancer Effects from Long-Term Exposure

Long-term exposure studies on the effects of 1,4-dichlorobenzene to humans could not be located in the available literature. However, chronic oral exposure studies have been conducted with laboratory animals. Rats exposed for 192 days to high doses of 1,4 dichlorobenzene (i.e. 376 mg/kg) had increased liver and kidney weights. The liver revealed evidence of cirrhosis and local necrosis. Similar liver and kidney changes were detected in rabbits exposed for 1 year to either 500 or 1000 mg/kg of 1,4 dichlorobenzene. Even at the low dose, rabbits suffered from body weight reductions, tremors, weakness, and focal necrosis of the liver.

Very little information was available in the literature on the teratogenic or fetotoxic effects of 1,4 dichlorobenzene. A case study of a pregnant woman who developed pica for 1,4 dichlorobenzene found that upon neonatal examination of the child there were no apparent abnormalities.

Carcinogenic Potential

1,4-dichlorobenzene is classified C, a possible human carcinogen. Sufficient animal data indicates that 1,4-dichlorobenzene is an animal carcinogen, but there is a lack of data to support the fact that the chemical is a human carcinogen.

1,4-dichlorobenzene has been shown to cause mitotic changes in somatic chromosomes which included separation of chromatids, chromosome bridges, and chromosome breakage.

BERYLLIUM

Uses

In normal daily life beryllium is used to make copper-beryllium alloys which are used in electrical switch parts, watch springs, optical alloys, valves, spot welding electrodes, shims, cams, and bushings. It is used structurally in the aerospace industry and in nuclear reactor cores.

Noncancer Effects from Long-Term Exposure

No information could be found in the available literature on the toxicity of ingested beryllium to humans. It has been noted in the literature that even the most water soluble salts of beryllium have been found to absorbed inefficiently in the gastrointestinal tract. This may effectively eliminate most internal exposure to beryllium through the oral route.

In long term bioassays with rats and mice, concentrations of 5 mg/L beryllium administered in drinking water had no adverse effect on the animals. Other studies of lesser quality have indicated a no adverse effect level at approximately 25 mg/L.

In the human long term low level exposure to beryllium dust has been associated with chronic pneumonitis and dermatitis. The pneumonitis is also associated with anemia, anorexia, and wasting which are its immunological aspects. Animal studies have confirmed the association between inhalation exposure to beryllium and pneumonitis.

Carcinogenic Potential

Epidemiological studies have found weak associations between occupational exposure to beryllium and lung cancer. Because of methodological limitations of these studies, it can not be conclusively determined that beryllium is a human carcinogen.

Beryllium has been shown to induce lung cancer via inhalation in rats and monkeys and to induce osteosarcomas in rabbits via intravenous or intramedullary injections. Based on mutation bioassays, beryllium has been shown to be a mutagen. Based on this weight of evidence, beryllium has been classified as a probable human carcinogen (i.e., B2).

CADMIUM

Uses

Cadmium's uses differ depending upon the form of the metal. Some of the common uses of cadmium are in electroplating bathes, as an assistant in dyeing and printing textiles, in photographic emulsions, to color glass, in batteries, and as a plastic and lubricant stabilizer.

Noncancer Effects from Long-Term Exposure

Cadmium is absorbed more efficiently from water (5%) than from food (2.5%). Humans exposed chronically to cadmium can suffer kidney damage which causes abnormal levels of protein to be found in the urine (i.e., proteinuria). The U.S. EPA has estimated that a safe level of exposure to cadmium from water and food to be 0.0005 and 0.001 mg Cd/kg/day, respectively. Chronic exposure to cadmium has had similar effects in laboratory animals, but at higher dose levels.

Carcinogenic Potential

Currently, there is not appropriate human data to support that cadmium is a carcinogen based on ingestion of cadmium. A number of animal feeding studies support the conclusion that cadmium may not be a carcinogen by this route.

There is marginal human data, but good supporting animal data that have linked the inhalation of cadmium to lung cancer. Based on the weight of evidence, cadmium is considered a probable human carcinogen (i.e., B1) by the U.S. EPA.

BARIUM

Uses

Barium has a wide variety of uses which vary among the many barium salts. Barium is used as an oil and grease additive, in barium soaps and chemicals, to refine beet sugar, and as an alkalizing agent in water softening. It is also used in carbon brushes for electrical equipment and in glass making.

Noncancer Effects from Long-Term Exposure

High barium concentrations in public drinking water supplies have been associated with elevated blood pressure in humans. Clinical studies to confirm this have not revealed any toxicity, including increased blood pressure, at a dose level as high as 10 mg/day.

Most animal studies that have been conducted have also detected no association between barium exposure and increased blood pressure. A single study with rats revealed increased blood pressure, but this was potentially attributable to other mineral deficiencies in the exposed rat population.

In occupational studies barium dust has been shown to cause baritosis. No symptoms of toxicity are evident other than workers have a significantly higher incidence of increased blood pressure.

Carcinogenic Potential

No appropriate information could be located in the available literature on the carcinogenic potential of barium in humans. Based on negative results in animal and mutation bioassays, barium does not appear to be a carcinogen. The metal is currently not classified by the U.S. EPA as a carcinogen (i.e., class D).

BENZENE

Uses

The main uses of benzene is as a raw product in the production of other aromatic organic chemicals such as ethylbenzene, and chlorobenzene. It is used by itself as a solvent.

Noncancer Effects from Long-Term Exposure

Two general effects on the human blood system have been associated with chronic benzene exposure: cytotoxic blood disorders and carcinogenic blood disorders. The main organ that is affected is the bone marrow which produces red and white blood cell precursors. The cytotoxic blood disorders include a plastic anemia (a significant reduction in white blood cells, red blood cells and platelets) and cytogenetic changes in the nucleus of bone marrow cells and circulating lymphocytes.

Based on the available literature, there is no clear evidence that benzene is a reproductive toxicant after long-term exposure to low levels of the chemical. In animal studies, despite some maternal toxicity and embryonic resorption, no strong evidence of teratogenesis has been seen in animal studies.

Carcinogenic Potential

Data from studies of persons with known exposure to benzene indicate that benzene is a human carcinogen. Acute myeloblastic leukemia is a cancer of the blood cells, which has been associated with benzene exposure. Of note in human case reports is the long delay between the cessation of a known benzene exposure and the onset of leukemia. The U.S. EPA classifies benzene as a Group A, human carcinogen.

APPENDIX V

TOXICOLOGY PROFILES FOR CHEMICALS OF POTENTIAL CONCERN

Toxicity profiles are presented for each chemical of potential concern at the site that was estimated to present a health concern (i.e., HQ > 1 or cancer risk > $1x10^{-6}$). Chemical effects associated with long-term exposure are presented along with the carcinogenic potential of the chemicals.

Adverse chemical effects may be quite different depending upon the magnitude and duration of exposure. Therefore, the most applicable effects associated with exposure to the Site would be due to low level and long-term exposure to the chemicals of potential concern.

The toxicity information contained in the profiles was obtained from one or more of the following sources:

- Patty's Industrial Hygiene and Toxicology
- Health Effects Assessment Summary Tables (1991)
- Casarett and Doull's Toxicology
- Integrated Risk Information System (IRIS)
- Health Effects Assessments Documents (HEA)

The following are summaries of health effects associated with exposure to the chemicals of potential concern at the Site calculated to pose a health concern.

ARSENIC

Uses

Alloy derivative for metals, especially lead and copper as shot, battery grids, cable sheaths, boiler tubes, gallium arsenide for electronic devices, special solders, medicine.

Noncancer Effects from Long-Term Exposure

Chronic worker exposure to arsenic compounds primarily affect the skin, mucous membranes, gastrointestinal tract, central nervous system and less commonly the liver and circulatory system.

There is some evidence from animal studies that implicates arsenic as a teratogen and reproductive toxicant. Mice exposed to arsenic as arsenate or arsenite during gestation had increased numbers of fetal reabsorptions, fetal deaths, and fetuses with exencephaly, and short jaws. The trivalent arsenite was much more toxic than then pentavalent arsenate at an equivalent arsenic dose.

Carcinogenic Potential

Arsenic compounds, particularly trivalent inorganics, have been associated with skin and lung carcinomas in humans. The U.S. EPA considers arsenic a Group A, human carcinogen.

United States Department of the Interior
Fish and Wildlife Service
Rock Island Field Office (ES)
1830 Second Avenue, Second Floor
Rock Island, Illinois 61201

TAKE PRIDE IN AMERICA

COM: 309/793-5800
FTS: 782-5800

In Reply Refer to:

June 20, 1991

Mr. Jerry Kelly
Warzyn Inc.
One Science Court
P.O. Box 5385
Madison, Wisconsin 53705

Dear Mr. Kelly:

This is in response to your request of 21 May, 1991 concerning available information on threatened and endangered species adjacent to the Woodstock Sanitary Landfill site in McHenry County, Illinois. We understand that Warzyn Inc. is conducting a Remedial Investigation/Feasibility Study (RI/FS) of the Woodstock Landfill, and is preparing an ecological assessment of the site as part of the RI/FS.

With respect to federally listed and proposed threatened or endangered species, the described area is within the range of four federally listed species:

Classification	Habitat	County	Common Name	Scientific Name
Endangered	Caves and riparian habitat	State-wide	Indiana Bat	*Myotis sodalis*
Endangered	Wintering	McHenry	Bald Eagle	*Haliaeetus leucocephalus*
Threatened	Dry to mesic prairies with gravelly soil	McHenry	Prairie bush-clover	*Lespedeza leptostachya*
Threatened	Wet grassland	McHenry	Eastern prairie fringed orchid	*Platanthera leucophaea*

We recommend that you contact the State Department of Conservation/Natural History Survey regarding additional pertinent information. The Illinois Natural History Survey may have more detailed species/habitat location information in computerized databases that would be much more useful to you.

These comments are provided as technical assistance only and do not represent the position of the Fish and Wildlife Service or the Department of the Interior on the project, or on any pending or forthcoming permits or environmental documents that may be required.

Please contact Melanie Young of this office if you should have any additional questions.

Sincerely,

Richard C. Nelson
Field Supervisor

MY:sjg

Illinois Department of Conservation
life and land together

LINCOLN TOWER PLAZA • 524 SOUTH SECOND STREET • SPRINGFIELD 62701-1787
CHICAGO OFFICE • ROOM 4-300 • 100 WEST RANDOLPH 60601
~~MARK FRECH, DIRECTOR~~ ~~KATHY SELCKE, ASSISTANT DIRECTOR~~
Brent Manning, Director

May 29, 1991

Jerry Kelly
Environmental Scientist
Warzyn, Inc.
One Science Court
P.O. Box 5385
Madison, WI 53705

Dear Mr. Kelly,

Thank you for sending the above project to this office for review for the presence of endangered or threatened species or natural areas. The Natural Heritage Database was examined and there are no known occurrences within the vicinity of the project area.

According to the Breeding Bird Atlas, however, a Cooper's hawk was identified nesting in the vicinity in 1983, suggesting suitable habitat exists for this species. No specific nest location was provided by the reporter, so the record was not included in our Database.

Please be aware that the Natural Heritage Database cannot provide a conclusive statement on the presence, absence, or condition of significant natural features in any part of Illinois. The reports only summarize the existing information regarding the natural features or the locations in question known to the Division of Natural Heritage at the time of the request. The reports should never be regarded as final statements on the site being considered, nor should they be a substitute for field surveys required for environmental assessments.

I cannot charge you for the search of our database, but I would like to urge your support of the Illinois Natural Heritage Database by contributing to the Illinois Nongame Wildlife Conservation Fund. The recommended donation for a standard information request is $30.00. Such contributions may be mailed to the above address. We appreciate your support of this important source of information.

If you need additional information or have any questions, please do not hesitate to contact me at 217-785-8290.

Sincerely,

Deanna Glosser

Deanna Glosser, Ph.D.
Endangered Species Protection
Program Manager

APPENDIX W

STATE STATUTES AFFECTING CITY OF WOODSTOCK RESOLUTION

W

CALDWELL, BERNER & CALDWELL
LAWYERS
100 1/2 CASS ST., WOODSTOCK, ILL. 60098
TELEPHONE 815-338-3300
FAX No. 815-338-0015

Reply to: P. O. Box 1289

WILLIAM L. CALDWELL
1908-1971
JAMES E. BERNER*
MICHAEL T. CALDWELL
WILLIAM L. CALDWELL, JR*
RICHARD T. JONES
JEFFREY A. ROUHANDEH

*MEMBERS OF WISCONSIN BAR

Thursday, June 11, 1992

RECEIVED

JUN 11 1992

CITY OF WOODSTOCK

Mr. John Isbell
Director of Public Works
Woodstock City Hall
Post Office Box 190
Woodstock, Illinois 60098

RE: WOODSTOCK MUNICIPAL LANDFILL
Our File No.: 8600-566

Dear Mr. Isbell,

I have your letter of June 4, 1992, which was accompanied by a photocopy of Section 8.3.1.4 of the Remedial Investigation Report pertaining to the Woodstock Municipal Landfill. In reply to the specific request of William Bolen, USEPA Project Manager for the Woodstock Municipal Landfill site, please be advised as follows:

The City of Woodstock is the owner of the land which comprises the Woodstock Municipal Landfill. As the owner, the City adopted a resolution, the full formal expression of the corporate policy of the City Council of the City of Woodstock, McHenry County, Illinois. That resolution made certain specific restrictions in the future use and utility of the property. The resolution had been recorded in the office of the Recorder of Deeds in McHenry County, Illinois.

Under these circumstances, Sections 1, 2, 3, and 30 of The Conveyances Act (Ill. Rev. Stat. 1989, Ch. 30, Sec. 1, 2, 3, 30) become effective. Those statutes provide as follows:

1.) **Livery of seizin unnecessary-Written conveyance sufficient**

"Livery of seizin shall in no case be necessary for the conveyance of real property; but every deed, mortgage or other conveyance in writing, not procured by duress, and signed by the party making the same, the maker or makers being of full age and sound mind, shall be sufficient, without livery of seizin, for the giving, granting, selling, mortgaging, leasing or otherwise conveying or transferring any lands, tenements, or hereditaments in this state, so as, to all intents and purposes, absolutely and fully to vest in every donee, grantee, bargainee, mortgagee, lessee or purchaser, all such estate or estates as shall be specified in any such deed, mortgage, lease or other conveyance. Nothing herein contained shall be so construed as to divest or defeat the older or better estate or right of any person or persons, not party to any such deed, mortgage, lease, or other conveyance."

2.) Effect of conveyance

"Every estate, gift, grant, deed, mortgage, lease, release, or confirmation of lands, tenements, rents, services or hereditaments made or had, or hereafter to be made or had, by any person or persons, being of full age and sound mind, and not procured by duress, to any person or persons, and all recoveries, judgments and enforcements had or made, or to be had or made, shall be good and effectual to him, her or them, to whom it is or shall be so made, had or given, and to all others, to his, her or their use, against the judgment debtor, seller, donor grantor, mortgagor, lessor, releasor, or confirmor, and against his her or their heirs, claiming the same only as heir or heirs, and each of them, and against all others having or claiming any title or interest in the same, only to the use for the same judgement debtor, seller, donor, grantor, mortgagor, lessor, releasor, or confirmor, or his, her or their heirs, at the time of the judgment, enforcement, bargain, sale, mortgage, covenant, lease, release, gift or grant made."

3.) Conveyances to use

"Where any person or persons be the owner of, or at any time hereafter shall be the owner of and in any premises, lands, tenements, rents, services, reversions, remainders, or other hereditaments, to the use, confidence or trust of any other person or persons, or of any body politic, by reason of any bargain, sale, fine, recovery, covenant, contract, agreement, will or otherwise, by any manner of means whatsoever, in every such case all and every such person or persons, and bodies politic, that have or hereafter shall have any such use, confidence or trust, in fee simple, for term of life, or for years or otherwise, or any use, confidence or trust in remainder or reversion, shall from thenceforth be the owner of, deemed and adjudged in lawful ownership, estate and possession of and in the same premises, lands, tenements, rents, services, reversions, remainders and hereditaments, with their appurtenances, to all intents, constructions and purposes in law of and in such like estates, as they had or shall have in use, confidence or trust of or in the same; and that the estate, right, title and possession that was or shall be in such person or persons, that were or hereafter shall be the owner of any lands, tenements or hereditaments, to the use confidence or trust of any such person or persons or any body politic, be from henceforth clearly deemed and adjudged to be in him, her or them that have hereafter shall have such use, confidence or trust, after such quality, manner form and condition as they had before, in or to the use, confidence or trust that was or shall be in them."

39.) Effective of recording as to creditors and subsequent purchasers

"30. All deeds, mortgages and other instruments of writing which are authorized to be recorded, shall take effect and be in force from and after the time of filing the same for record, and not before, as to all creditors and subsequent purchasers, without notice; and all such deeds and title papers shall be adjudged void as to all such creditors and subsequent purchasers, without notice, until the same shall be filed for record."

The cumulative effect of these statutes when read together is that any person, firm or corporation taking title to the subject real estate subsequent to the City of Woodstock is bound by and prevented from using the property in violation of the covenant reflected in the resolution of the City of Woodstock. The City of Woodstock has voluntarily divested itself of an incident of ownership by limiting the use of the property in the manner specified in the resolution. No subsequent purchaser can use the property in violation of the restriction created by the resolution of the City of Woodstock.

The City of Woodstock has two (2) rights of enforcement as to the restrictive covenant. First, the City can zone the property into a use classification under the local zoning ordinance to insure that no use is located on the property which would require a well. The City is authorized to specifically enforce the limitations in the zoning ordinance by injunctive action under the terms of Section 11-13-15 of the Illinois Municipal Code (Ill. Rev. Stat. 1989, ch. 24, Sec. 11-13-15). Second, the City, as makers of the covenant, can invoke the injunctive powers of the court to compel compliance with the covenant. {Batavia Mfg. Co. vs. Newton Wagon company, 91 Ill. 230 (1878)}

Trusting that this answers Mr. Bolen's question, I am

Yours very truly,

Michael T. Caldwell

Michael T. Caldwell

MTC:mb